DOCTOR OF PHILOSOPHY

The moderating role of personality on the effectiveness of implementation intentions aimed at increasing engagement with university mathematics support services

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The moderating role of personality on the effectiveness of implementation intentions aimed at increasing engagement with university mathematics support services

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ABSTRACT

The aim of this thesis was to explore how personality traits such as psychoticism and extraversion could be used to predict the effectiveness of implementation intentions when used to promote the use of Mathematics Support Centres within institutions of Higher Education. Study One aimed to firstly investigate if there were differences in personality and mathematical ability between students from different courses. Secondly, the study aimed to explain any relationship between personality and mathematical ability for undergraduate students. Kruskal-Wallis and Mann-Whitney U tests were carried out and suggested that there were differences in mathematics diagnostic scores and psychoticism between students from different subject groups. Statistically significant correlations were found between mathematics diagnostics scores and psychoticism for Business studies (positive correlation) and Psychology (negative correlations) students. The results suggest that students may benefit from differing methods of teaching mathematical concepts, especially in the cases where students are averse to working in groups and collaboratively. Study Two investigated the use of implementation intentions to increase the total time students spent engaging with mathematical study outside of formal lectures and seminars. Wilcoxon signed rank tests were carried out and suggested that implementation intention could be used to improve the total amount of time students spent engaged with mathematical study. Study Three looked at the use of implementation intentions to increase the use of the Mathematics Support Centre at Coventry University. The Aligned Rank Transform technique was used to facilitate the use of the analysis of variance test. Data suggested that the greatest increases in Mathematics Support

Centre usage was by those who had intentions to use the support services regardless of whether implementation intentions had been formed or not. Forming implementation intentions did not appear to change the amount of time students spent using the Mathematics Support Centre.

The main findings of the thesis are that implementation intentions were found to be ineffective in improving the amount of time students spend using the Mathematics Support Centre. It is suggested that this could be an individual's perceived need to use the support services reducing the effectiveness of the implementation intentions ability shield the individual from the performance of behaviours that do not help reach the goal of improving mathematical ability. At present the biggest improvements in usage would be derived from improving awareness of the Mathematics Support Services and helping students to realise the importance of the support. Future research needs to explore why this type of intervention does not appear to work in the context it was used and how it could be adapted for use as a viable strategy for increasing uptake of the support services.

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CHAPTER 1 THE DECLINE IN MATHEMATICAL ABILITY OF STUDENTS IN HIGHER EDUCATION

Universities in England have for many years observed a mismatch between the mathematical capabilities of new undergraduates and the mathematical requirements of various degree programmes. This chapter discusses the problem of this mismatch and also the strategies employed by universities to address the problem relating to mathematical capabilities insufficient for the course demands. The discussion will focus on Mathematics Support Centres that have been set up by many universities to support students who require help with mathematics, and will explore some of the reasons why some students who need support do not engage with these services.

1.1 WIDENING PARTICIPATION AND THE MATHS PROBLEM

Mathematical skills are important in both the workplace and for the successful completion of the vast majority of Higher Education courses of study. Although the courses of study in Higher Education have varying amounts of mathematical content, the importance of being numerate in general is still high. This section presents evidence which shows that students entering university come from increasingly diverse mathematical backgrounds and consequently the mathematical skills of students have become increasingly varied. Importantly, this discussion identifies the mismatch between the actual mathematical capabilities of students and the expectations of universities and industry.

1.1.1 THE "MATHS PROBLEM"

The importance of mathematics in today's economy has been highlighted by Smith (2004: 12). Most importantly, Smith highlights how a numerate workforce is required for the country to remain competitive with other nations:

> *Advanced economies need an increasing number of people with more than minimum qualifications in mathematics to stay ahead in international competitiveness and, in particular, to effectively exploit advances in technology. An adequate supply of young people with mastery of appropriate mathematical skills at all levels is vital to the future prosperity of the UK*

As part of the movement towards widening participation in Higher Education, over the past two decades many UK institutions have relaxed the entry qualifications for degree courses. The result of this has been an increase in the number of students entering Higher Education combined with greater variation in educational and social backgrounds. A by-product of the influx of new students is a greater variation in current and potential attainment of the students (Hawkes and Savage 2000). In particular, the number of students who are entering universities with an inadequate mathematical background resulting in an inability to cope with the mathematical demands of the chosen course of study has risen substantially (Williamson, Hirst, Bishop and Croft 2003).

Students who have been identified as not having the mathematical skills to cope with their chosen course of study have also been found to be more prone to failing or dropping out of University (Bourn 2002, 2007). For example, students undertaking Nursing degrees are often required to undertake a numeracy examination involving questions related to drug dosages. Failure to pass the tests can result in the student not progressing to the next year of the course.

A major difference between England and other parts of the world is the non-compulsory nature of mathematics study once the compulsory phase of education has been completed (Wolf 1997, Nuffield Foundation 2010: 15). This feature sets the English education system apart from the majority of other developed countries where mathematics is to some extent compulsory in the post-compulsory phase of education, and is often seen as an essential deciding factor for acceptance onto university courses. As a result, English university students may have avoided mathematics immediately prior to entry onto their university course. This can lead to a mismatch between a student’s capabilities and the demands and expectations arising from staff at universities. This problem is widespread and observable in many different disciplines (Smith 2004). Psychology is a good example of this; for example, Ruggeri, Dempster, Hanna and Cleary’s (2008) study of 196 psychology students

(1st year = 158 and 2nd year = 38) found that only 46.7% reported knowing about the compulsory statistics components of their course prior to entry. This could help to explain why many students intending to take psychology do not undertake post-compulsory mathematics study and as a result find the statistical components of a psychology degree challenging.

1.1.2 Problems in achievement

The problems relating to the mismatch between the mathematical expectations of universities and students seem to be a particular issue for subjects which demand some form of mathematical competency as part of the core curriculum of the subject, but which are not overtly mathematical subjects. Examples of the problems in numeracy can be seen in many disciplines. For example, Jukes and Gilchrist (2006) looked at second year nursing students' ability to consistently and accurately perform drug dosage calculations, and found that the percentage of students who answered 90% or more of the questions correctly was as low as 8%. These data support the earlier work done by Ashby (1997), whose assessment of 100 registered nurses found that only 44% answered at least 90% of the questions correctly; furthermore, nearly 20% of those assessed failed to achieve a score of 70%. Mathematical difficulties are not restricted to nursing undergraduates but have also been found to exist amongst nurses in the workplace. Wright (2006) reported that many nurses and nursing students found topics related to fractions and interpreting information from charts to be problematic and these mathematical inadequacies originated both from their past education and also their attitudes towards mathematics (such as self-confidence and enjoyment of mathematics).

Nurses are not the only population of students who demonstrate difficulties with mathematical concepts. A study of 890 Psychology 1st year undergraduate students (from eight universities) by Mulhern and Wylie (2005) was conducted using a 32-item mathematics diagnostic test (covering calculation, proportionality and ratio, probability and sampling, algebraic reasoning, estimation, graphical interpretation). Their results showed that in most cases the mean proportion of correctly answered question items was 0.4 suggesting that there may be mathematical deficiencies in many undergraduate psychology students. Furthermore, the mathematical skills of psychology students from 2002 was significantly lower than those observed in a similar cohort of students from 1992 (Mulhern and Wylie 2004). Mulhern and Wylie's results, combined with those from a similar study (Greer and Semrau 1984) which looked at the mathematical skills of psychology students in 1984, suggest that between 1984 and 2004 psychology students' mathematical competency declined. Furthermore, a report by Kounine, Marks and Truss (2008: 8-12) suggests that the overall standard of mathematics has been declining since the mid-1970s, to the extent that students can achieve a good pass at GCSE with little conceptual understanding of the mathematics being studied. Similarly, Ofsted (2009: 51-52) highlights that students' mathematical competencies are focused more on the performance of mathematical procedures and less on the underlying concepts involved. The decline in mathematical competence has also been observed within

English universities' science, mathematics and engineering departments (Hawkes and Savage, 2000).

1.1.3 DISENGAGEMENT FROM MATHEMATICS

As mathematics post-16 is not compulsory in England, many students choose not to study mathematics beyond GCSE level. There are many reasons why students choose not to study mathematics post-16. These reasons relate to self-confidence, self-efficacy, attitudes towards mathematics and past experiences. For example, a study by Yusof and Tall (1994) used a short questionnaire (5 point Likert scale) to look at the attitudes towards mathematics (10 items) and attitudes towards problem solving (8 items) of undergraduate students studying industrial science and computing courses. Their study attempted to change the attitudes of the students through an intervention. The intervention consisted of a 30-hour problem-solving course (split over ten weeks), which aimed to encourage participants to solve a variety of mathematical problems co-operatively (in small groups of 3 to 4 students) and also to facilitate reflection on the problem solving process they were engaged with. Although the instructor facilitated the sessions by encouraging collaboration and reflection, no indication was given to the students of the correctness of their solutions. It was found that, prior to the intervention, participants who were not confident in mathematics predominantly thought of mathematics as mostly about remembering facts and memorizing techniques. After the problem solving intervention these students thought they could better comprehend the mathematics and thought it was less about memory and more about solving problems and relating linked ideas.

Other research suggests that students' perceptions of mathematics not only play an important role with student engagement but also students' choices about further mathematics study. A study by Brown, Brown and Bibby (2008) looked at GCSE students and found their decisions to study mathematics at A/AS level were based largely on their perceptions of mathematics. Their reported study was part of a larger project and results from 5 questions that were relevant to engagement with further study of mathematics were reported (i.e. 1. Gender and predicted GCSE grade, 2. Circling one or more of ten words describing their feelings about mathematics or adding their own words, 3. Did the students intend to undertake A-level study and in which subject areas, 4. Were they going to choose mathematics? 5. Open ended question explaining their decision to study or not study mathematics). Major reasons for not continuing with mathematics were because students felt that mathematics was difficult, not enjoyable, irrelevant or boring. This suggests that some of those who choose non-mathematical courses in tertiary education may do so not for reasons solely related to their vocational preferences but also to some extent as a method of mathematics avoidance. That is many students choose not to continue their studies of mathematics post-16 due to their past experiences and perceptions of mathematics (The Royal Society 2008).

The above study suggests that students' views on mathematics influence how they engage with the subject. However, it is important to note the limitations of the instruments that have been used to measure attitudes and reasons for disengagement with mathematics. For example, the instruments used by Yusof and Tall (1994) to measure attitudes towards mathematics and problem solving consisted of 10 and 8 question items. These items were limited to how mathematics is learned and confidence in mathematics; but did not offer a means to capture other attitudes towards mathematics that may well contribute to their attitudes (e.g. social or peer influences). The study by Brown, Brown and Bibby (2008) discussed the responses from 5 questions, which allowed students to better express their feelings towards mathematics due to the inclusion of free response questions. The literature on attitudes towards mathematics highlights some of the reasons why students disengage with mathematics at university and prior to entry. However, while the question items allow expression of students' feelings (i.e. 'I find maths difficult', 'I find maths interesting') to be associated with students' intentions of future study, questioning of this kind does not necessarily fully explain why a student disengages with mathematics (e.g. why does the student find mathematics difficult? Why do they find it interesting?) It is possible that there are more underlying explanations of why students disengage from mathematics that are not apparent from general attitudes questionnaires.

1.1.4 Consequences for universities

As described in Section 1.1.3 above, there are a number of reasons (including feelings that mathematics was difficult, irrelevant or boring) why students may choose to avoid studying mathematics after they have completed their compulsory mathematical study (e.g. GCSE level). However, this avoidance cannot be maintained indefinitely as mathematics avoidance is becoming increasingly difficult: many jobs, even those which may be thought of as unskilled or requiring low academic achievements, still may require at least a grade C in GCSE Mathematics (Kounine et al. 2008). For example, in warehouse or manual labour jobs, employees may be involved in checking quantities of delivered stock and correctly working out total costs of items in addition to calculations involving time or use of ratios for mixing cleaning solutions (Hudson 2007). Other research (Hoyles, Wolf, Molyneux-Hodgson and Kent 2002) also highlights the importance of mathematics within the workplace and how many vocations, which may have been thought of as non-mathematical, can require employees to use mathematics. Hoyles et al. (2002) also note that mathematics is a requirement at many levels of employment. Furthermore, many university courses such as psychology, business studies, nursing and economics require some level of competence in numeracy and mathematics regardless of what students may regard as important or relevant.

Due to the identified problem of numeracy and mathematical competence of students as they enter university there would seem to be an immediate problem relating to the mismatch between students' capabilities and the demands and expectations arising from staff at universities. Although the problem is widespread and observable in many disciplines (Smith 2004:12), the focus of this thesis will be on the problems encountered by students who are studying 'non-mathematical' degree courses i.e. where the entry requirement with regards to mathematics does not exceed GCSE mathematics (grade C). During these courses students will encounter and be required to understand mathematical concepts and procedures up to and possibly in excess of that required for some elements of an A-level mathematics course. For example, in many social science and health courses, students are expected to learn and apply advanced statistical techniques through the use of statistical packages such as SPSS, R and SAS.

The material reviewed in this section has shown that mathematics is an essential component of many courses and that a sizeable proportion of students appear to demonstrate mathematical difficulties. The existence of these difficulties in many of the students has been a problem for over a decade and raises the question of what strategies are being employed to address the issue. Current strategies for supporting students with their mathematical studies will be discussed in the next section (1.2) focusing in particular on the Mathematics Support Centres designed to provide drop-in services and bookable support opportunities.

1.2 USAGE OF CURRENT SUPPORT SERVICES IN HIGHER EDUCATION

This section discusses the strategies employed by universities to support students and remedy the mismatch between students' understanding of mathematics at point of entry to university and course requirements. One such strategy is the creation of Mathematics Support Centres focused on drop-in and appointment style support provision for students with problems understanding mathematics. What is highlighted by this discussion is that although the services may be beneficial to those who choose to make use of them, there should be concern about students who need the support but who do not seek out and engage with the support provision.

1.2.1 Mismatch between expectation and reality

In the previous section mismatch between personal mathematical skills and the skills that universities take for granted as being pre-requisite to entry was discussed. The identified mismatch can result in students being underprepared for their university studies and consequently increases the probability of premature withdrawal or failure before completion (Quality Assurance Agency for Higher Education 1998). The issue of retention is of importance to the Higher Education Funding Council for England (HEFCE) who as part of the widening participation agenda has worked with many universities to fund projects aimed at increasing teaching quality and student retention. Examples include a number of the Centres for Excellence in Teaching and Learning (CETL) and the Student Retention Grants Programme, which aims to assist institutions of Higher Education to disseminate good practice with regards to the retention of students (HEFCE 2010).

The mismatch between capabilities and course demands can be viewed in several ways, which in turn affects the strategies that can be used to address the problem:

1. To assume that the problem originates in the teaching and learning experiences of the students prior to entering university and that it is not the university's problem. With this idea some change (possibly non-trivial) may need to be made to the way students are taught whilst in further education to ensure that future students are adequately prepared for university entry. In England the need to provide a better quality of education for young people in schools and further education is of current political discussion. The Office of Qualification and Examinations Regulation has recently released a three year plan to help ensure that the education young people receive is adequate to prepare them for future employment and study (Ofqual 2012). Furthermore, Ofsted (2012) have also suggested that standards in both schools and further education need to be raised in order to help improve the education received by students in schools and further education institutions.
2. To assume that the problem originates in the teaching and learning experiences of the students prior to entering university and that the university can take steps to assist the students to make the transition from further to higher education and lessen the gap between the students' capabilities and the university's expectations.
3. To believe that the whole educational system needs to be overhauled and a new more cohesive educational framework needs to be constructed where all stages (primary, secondary and tertiary) are more integrated such that the transitional boundaries are less explicit.

4. To believe that the student and parents need to take responsibility for learning and should engage with supplementary home tutoring or top-up teaching.

Of the four actions described above it would appear that university educators are acknowledging the fact that the problem exists (Bourn 2007: 32) and needs to be addressed by the educators at university (Smith 2004). The role of colleges in supporting students to become more numerate was highlighted by Casey et al. (2006). Their study examined the impact of embedding literacy and numeracy teaching with students who were weak in some areas of numeracy within vocational courses such as Health and Social Care, Hair and Beauty Therapy, Construction, Business and Engineering. They found that 90% of students involved with embedded courses achieved a mathematics qualification compared to 73% on the non-embedded courses. For some institutions the problem can be attenuated by increasing course entry requirements; however this option is not always available and may not always work if it is available. Also the idea of restructuring and overhauling current educational frameworks for delivering mathematics in primary and secondary schools is not an easily attainable goal which can be accomplished quickly. Option 2 would seem to be the view many institutions (e.g. Coventry University, University of Limerick, Loughborough University) have taken up. These institutions are exploring how current students and those who will be entering into university in the near future can be supported in their study of mathematics.

1.2.2 *UNIVERSITY SOLUTIONS*

Many different strategies/solutions currently exist at both institutional and national levels to help students to improve their mathematical skills once in university to address the problem of mathematical competencies in their student intakes. In the majority of cases the support is available for the full duration of the course being studied (i.e. not limited to just 1st year students). Some of the solutions currently employed include:

- The addition of a foundation year/extra year – the addition of a foundation year can bridge the gap between the skills of the students and the expectations the university has for a typical 1st year student. This does lengthen the duration of the course and increase the burden on students who need to pay their own fees (e.g. the Engineering and Science Foundation Year Programme offered by Nottingham University. After successful completion of the foundation year, students can progress onto Year 1 of a degree course).
- Pre-sessional bridging course – this is a short course which is run prior to the official start of term. These courses aim to remove the 'shortfall' or mismatch in students understanding before the official start of the university course. A report by LTSN MathsTeam Project (2003a: 28-34) describes a number of these services in detail.
- Additional Teaching – supplementary sessions where students can meet with a tutor to discuss mathematical problems, these are in addition to those

scheduled as part of the course (e.g. nursing mathematics workshops run at Coventry University to support nursing students with calculations involving such topics as drug dosages, ratios, percentages and fractions).

- Creation of various learning materials – Many materials have been created so that the students can learn more effectively on and off site. They include online support/ paper-based materials/ CD-ROMs/ podcasts/ virtual worlds etc. The Maths Support Service at Cardiff University, for example, has made available a number of online resources that have either been created by themselves or repurposed from existing materials. Furthermore, topics have been grouped together by relevance to different subject areas, such as psychology or health sciences. Many institutions also make use of the resources available on the 'mathtutor' website (http://www.mathtutor.ac.uk).
- Creation of mathematics support services – areas where students can drop in and ask mathematics questions to a member of staff. These tend to be rooms where students can come in and study while a member of staff can assist students as and when required. Mathematics Support Centres have been set up at a number of institutions, for example Coventry University, Loughborough University, London South Bank University and the University of Nottingham.

Some of the strategies are voluntary and some are pre-requisites for entry onto degree programmes. However, regardless of how good a given method of improving students' mathematical skills is, it is still reliant on the individual making use of or engaging with the methods. Engaging with the support provision does not guarantee an improvement in the attainment of students, neither can increases in mathematical attainment be attributed to any particular method of support. However, it is impossible for students who do not engage with the support available to derive any improvement from the service regardless of the effectiveness or helpfulness of the support provision. This suggests that strategies to improve the usage of such support services are required.

1.2.3 Maths Support Centres

One service that has appeared in as many as 85% (Perkin, Lawson and Croft 2012) of institutions of higher education in a number of forms is the support centre. Mathematics Support Centres/ drop-in support centres tend to operate from a fixed location on the university campus with the possibility of smaller outreach locations scattered around the campus. Some solutions such as the Maths Café (Portsmouth 2008) run by the University of Portsmouth are not fixed to one location; instead they offer support in a number of locations around the university, typically in informal locations such as food outlets.

The services are operated by the university and are run in addition to the courses that students are enrolled on. The aim of the services is to provide additional help to students who request it. Support is offered in the form of one-to-one tutorials/

vocational or course specific maths workshops/ open-to-all drop-in sessions etc. Students can in many cases visit without a prior appointment and seek assistance with their mathematical problems through the drop-in service, though some support is appointment only (e.g. specialist statistics support).

Further information about the support described above can be found in Appendix 1.1 where a brief summary of the mathematics specific support available at a number of institutions around England is given [i.e. Centre for Learning Support and Development (London South Bank University), QMW (University of Nottingham) and the Mathematics Support Centre (sigma, Coventry University)]. As part of a previous study looking at attitudes towards mathematics and the support provision offered at various Mathematics Support Centres in other institutions (Bhakta, Lawson and Goodband 2007), visits were made to London South Bank University, University of Nottingham and Coventry University and members of staff were interviewed in an effort to better understand what provision is being made for these students and also to make an estimate of how effective the available provision is. Staff were able to give some insight as to possible reasons why students may or may not use the support on offer and also the effectiveness of the services being offered. Support services at all three institutions stressed that the support being offered was not intended to be any form of replacement for teaching and learning already available at their respective institutions. In all cases it was intended as a supplement which was available to students departmentally and university-wide. The interviews, which took place during the 2006/ 2007 academic year, suggested that, from the support providers' point of view, students were generally happy/pleased/grateful for the support that was being offered. Staff indicated that the evaluation of the support provision at these institutions was through data obtained from overall student achievement (university wide and department data where possible), usage statistics and feedback from students who had made use of the support provision. In some cases the feedback from support centre staff suggested that students would prefer more contact time with the support centre staff. Students were grateful for the time offered by the support providers as it was felt that lecturers (those teaching and lecturing on the students' course of study) did not always have the time or inclination to be able to help students. Data are not available to ascertain if the improved understanding resulted in higher achievement on coursework or exam results. Data involving comparisons of improvement in comparison to a control group were not available at the time of the interviews. The evaluations and the claims made by service providers as to the effectiveness of the support provision should not be taken at face value as these evaluations were based on data from students who made use of the services and little to no comparison data were available from students who did not use the services. These students did provide useful feedback to the staff on how effective the service was and also how it could be further improved. From the interviews with the staff from London South Bank University, Coventry University and Nottingham University it would appear that in some cases (where data was available), those students who made use of Mathematics Support Centre type services did benefit (through observations by staff of improvements in students understanding of specific mathematical topics after the use of the service). Support providers did acknowledge this and indicated that departmentally (where a large proportion of students from a particular department attend) there were observed improvements in overall mathematical competence. Although there was a reported improvement in mathematical competence, it was not possible to ascertain if the improvement was due to the support provision or through maturation. It was also noted that the support staff felt that students generally had a good attitude towards the service and the staff offering the support (data obtained from evaluation forms).

Archived usage data from the Mathematics Support Centre at Coventry University are presented in Table 1.1 (below). The data in Table 1.1 suggest that during the 2008 to 2009 academic year the number of students from the faculty of Health and Life Sciences represented a very small proportion (0.7%) of the students who made use of the support services on offer compared to the Faculty of Engineering and Computing (88.7). It was suggested in Section 1.1.2 that the mathematical skills of undergraduate students from non-mathematical disciplines had declined (including those from psychology and nursing courses). As a result of the mismatch between their mathematical skills and the course demands, it would be expected that more students from the Faculty of Health and Life Sciences would have made use of the services.

Table 1.1: Archived usage data from the Mathematics Support Centre suggested there were 3798 recorded uses of the centre during the 2008 to 2009 academic year.

Faculty	Engineering and Computing	Business Environment and Society	Health and Life Sciences	Unknown	Total
Uses of the Mathematics Support Centre	3367 (88.7%)	152 (4.0%)	27 (0.7%)	252 (6.6%)	3798
Unique Individual Users	712	96	16	104	928

The low usage by those in the Faculty of Health and Life Sciences could be explained by the location of the services; the Maths Support Centre was located within the main Faculty of Engineering and Computing building at that time. This could explain the usage, however no data were collected to support this. It should be noted that the data in Table 1.1 were only representative of participants who chose to record their attendance either using their university card or by means of a sign in sheet (this may account for data where the students' faculty is unknown). Data were only available for the number of uses by the students and not the duration. Furthermore, the data suggest that those who have used the support services have returned to make additional use of the services (as shown by the number of unique users being considerably less than the number of uses of the Mathematics Support Centre). However, these data on their own do not prove or even suggest that the majority of users return for additional support. Without more detailed data which examine the actual number of visits per user, the data from Table 2.1 could be interpreted in many ways e.g. for the Engineering and Computing users the data could be interpreted as all 712 users returning for at least 3 further visits (which could be an indicator of a successful service with all users returning). However, an alternative interpretation could be that the 2655 additional visits were due to a small handful of repeat users (e.g. 20) who make considerable use of other services and not necessarily only the one to one support. The alternative interpretation would suggest that the other 692 users did not make return visits, this would be far from ideal if these users were unhappy with the service on offer. The reality of where between the two interpretations the actual distribution of usage would be is impossible to gauge without data that looks at the usage patterns of individual users.

Evaluations of the support provided by Mathematics Support Centres has suggested that the provision is effective in improving the mathematical skills of students for those students who attend. A report by Lawson, Croft and Halpin (2001) aimed to assess the effectiveness of Mathematics Support Centres that had been set up by many institutions of higher education in the UK. Of the 95 institutions contacted 46 had some form of Mathematics Support Centre. It was found that only 4% of users were from the Health and Social Sciences discipline. Another important finding from their research was that a major barrier as identified by the universities to the effectiveness of the provision was the small number of students who were making use of the services (Lawson *et al*. 2001: 15-17). A more recent analysis of the effectiveness of a Mathematics Learning Centre based at the University of Limerick by Gill and O'Donoghue (2007) suggests that the number of individual students using the centre increased by five times and the number of appointments more than doubled between 2001/2002 and 2005/2006. Furthermore, Gill and O'Donoghue point to students' mathematics achievement data as a possible indicator of the effectiveness of the support provision. The percentage of students having a failing grade in the mathematics modules taken by science, engineering, technology and mathematics students decreased since the introduction of the Mathematics Support Centre. In addition to the Mathematics Support Centre, the University of Limerick also offered supplementary support tutorials. Data suggest that the mean score for the at-risk students (those scoring less than 50% on a diagnostic test) who attended support tutorials was higher than for those who did not attend. It was noted that, although the data support the idea that those who used the support provision were also improving their mathematical capability, it was impossible to confidently attribute these improvements to the use of the Mathematics Support Centre. It is important to continue the development and use of 'hard' measures to gauge the effectiveness of the provision available rather than 'soft' measures such as feedback from students who have received support and may be biased (Croft 2008). Data from support providers and past research suggests that the use of Maths Support Centres is beneficial for students who make use of them. However, the fact that there are students who continue to have areas of mathematics and numeracy that need to be developed some time after the start of their course seems to suggest that the service could be ineffective for some students.

These two seemingly contradictory views can be reconciled by acknowledging that there are many students who do require the support yet are not making using of the service (this explains why some who arrive with low mathematical skills may continue to have lower mathematical skills than their peers). However, the issue of non-engagement of students who have weak mathematical skills is a major concern that has not been fully addressed. As part of a larger study Symmonds, Lawson and Robinson (2008) interviewed a total of 92 students at Loughborough University, of whom 19 were found to have failed one or more mathematics modules during their first or second year studies. The research highlights that of the failing students there was a recurring theme of lack of engagement with the Mathematics Learning Support Centre (MLSC) at Loughborough University. From the focus groups and interviews, a number of reasons were found why students, particularly the weaker ones, did not use the service. *Not knowing the location of MLSC* suggests that the services and location were not promoted adequately. *Perception that the service was unnecessary* suggests that students may have felt their mathematical skills were adequate and did not need improvement. Others felt *embarrassment and a perceived stigma attached to using a support service*, this could be a strong motivation for not using the services if students placed great importance on how others may perceive their usage of the support services. Some students felt they had *too many problems* and that the support services would be unable to support them due to the plethora of mathematical questions they may have. Students also had the perception that the *MLSC was a support service geared towards students studying maths intensive courses.* These kinds of ideas where students from non-mathematics courses felt that services were geared towards those from courses such as Mathematics and Engineering whilst being poorly equipped to support students from other disciplines could be a major problem that explains why students from non-mathematical courses were low users of the services at Coventry University and elsewhere.

Recommendations made by Symmonds et al. (2008) include better advertising and promotion of the support services with a focus on weaker students. They also suggest that students are encouraged to actively reflect on their own learning, particularly when it comes to pinpointing weaknesses and subsequently taking action to address the weakness (e.g. considering the use of the Mathematics Support Centre). Furthermore, a study by Grehan, Mac an Bhaird and O'Shea (2010) suggests that those who make use of the Mathematics Support Centres had higher chances of success in mathematics based exams. Importantly, Grehan et al. (2010) interviewed students who had to repeat their 1st year of study. Their findings suggest that despite the benefits of engaging with the support, those who tended to be weaker students had not engaged with the Mathematics Support Centre and also were not actively engaging with lectures and tutorials. Reasons for the lack of engagement with the support services were lack of motivation, being unaware of the support provision and fear (of failure, of showing lack of ability, of being singled out and of the unknown, in particular the Mathematics Support Centre that was new to them).

In summary, past research suggests that there is merit in students' using the Mathematics Support Centres, though as Gill and O'Donoghue (2007) point out the increase in achievement or mathematical ability cannot directly be attributed to just the use of a Maths Support Centre. Furthermore, previous attempts at evaluating the effectiveness of the support provision have been methodologically limited. However, the use of the Maths Support Centre may trigger the start of other constructive behaviours by the learner. There is also the issue of weak students who are not engaging with the services on offer as identified by Grehan et al. (2010) and Symmonds et al. (2008). The quality of the support and its potential effectiveness in raising or improving the mathematical skills of students becomes irrelevant if students do not use the service.

The next section will discuss in greater detail the reasons why students may not engage with the support on offer. The research outlined will address the problem of engagement with support services and the study of mathematics by students on non-mathematical courses who do not make use of services even when it is in their best interests to do so (i.e. they have identified areas of mathematics where their skills could be improved).

1.2.4 Engaging with mathematics support

In Section 1.1 the implications for universities of the widening participation agenda on the mathematical skills of students at university was discussed. So far, Section 1.2 has aimed to discuss the strategies used by universities to address the differences that exist between the mathematical capabilities of students on entry and the mathematical expectations of the diverse courses of study at University. A major focus was placed on the Mathematics Support Centre type of provision that has become prevalent in over 50% of institutions in various forms. As highlighted in Sub-Section 1.2.3, there is evidence to suggest that provision of these types of centres is worthwhile in that there are measurable differences in attainment between those who do and do not engage with the services. There has also been some research that looks at why some students do not engage with the services. Of particular interest were the weaker students who were found to be disaffected and made little to no use of the Mathematics Support Centres. Furthermore, past research also suggests that those students from courses where A-level mathematics was not an entry requirement or those from degree courses considered non-mathematical in relation to Physics or Engineering felt that the Mathematics Support Centre type environment was not the place to receive relevant support (possibly considered unfit for the purpose). An example of this was for students from the Health and Life Sciences (Coventry University) which accounted for 1.7% of users and 0.7% of the total visits during the 2008/ 2009 academic year.

In light of the above it seems sensible to focus attention on those students who are not using the services with a view to helping those who are weaker and in most need. It has been indicated that many students who do not use the mathematics services do so due to a number of reasons including:

- Not enough knowledge of the service provided by the Mathematics Support Centre (including location and opening hours)
- Perceived inappropriateness of the service for their needs
- Fear of appearing ignorant about mathematics
- Perceived lack of need for support (misconception that mathematical capability is adequate)

Students' study behaviours and predispositions towards mathematical study, be it in formal or informal settings, may be influenced by a number of factors which may not be known without some kind of measurement, questioning or observation of the student. As the use of the Mathematics Support Centre has been identified as possibly promoting improved mathematical attainment there would appear to be the need to increase students' engagement with the service through some intervention. One suggested method (Symmonds et al. 2008) was to increase students' reflective study abilities and ability to act on their own weaknesses. The goal of an intervention would be to change students' behaviour such that the support services are used rather than ignored.

It is quite possible that a change in behaviour may not have an observed impact on students who are not having difficulties with mathematics. However, the impact of improved usage may increase the chance of changing the outcome from a fail to a pass (bearing in mind this change is not a guaranteed outcome) for those students in danger of failure on their chosen course, not due to lack of understanding or knowledge in their main discipline but due to inadequacies related to mathematics. Smith (2004: 95) argued that universities need to "…accommodate to the students emerging from the current GCE process". At the heart of the "accommodation" is a need to encourage students to engage in mathematical study actively, either on their own, with their peers, or by taking advantage of support offered by the university. For this to happen, most students need to change their study behaviours. However, the problem is how to encourage or bring about this change in behaviour such that more students engage actively with mathematical study for longer. Changing behaviour however is not a simple task as will be discussed in depth in the next chapter.

1.3 SUMMARY

This chapter has shown that the mathematical capabilities of students has changed over the past 20 years. The change has resulted in a mismatch between the expectations of universities and the mathematical capabilities of students beginning their studies. In response to the mismatch, a number of strategies have been used to support students in improving their mathematical skills. However, this chapter has highlighted that the effectiveness of these strategies is difficult to measure, particularly where samples are composed only of students who have used the support services. Of importance are those students who so not make use of the services and need to develop their mathematical skills.

CHAPTER 2 PSYCHOLOGICAL BARRIERS TO ENGAGEMENT

In the previous chapter it was shown that the use of Mathematics Support Centres has the potential to improve the mathematical skills of those who use the service. However, it was also suggested that many students who were weaker and more in need of the service were unlikely to use it. We therefore need to understand how to change the behaviour and predispositions of individuals with poorer mathematical skills in order to remove some of the barriers to using these types of services. To this end, psychological models of behaviour change are examined in this chapter in order to understand how best to tackle the problem of non-attendance amongst students on non-mathematical degree courses.

In Chapter 1 it was identified that there is a need to improve the mathematics capabilities of undergraduate students across all disciplines. Mathematics Support Centres are now widespread and there is a growing body of evidence to suggest that these are helping to improve the mathematical capabilities of undergraduate students. However, it was also noted that these services were not always being made use of by all those students who needed the support. This section discusses three popular psychological models of behaviour change that are used in the explanation, prediction and modification of behaviour within several contexts. Importantly, each of the models incorporates an evaluative component resembling an attitude, although each has a slightly different view of how the evaluative construct is formed and the role it plays in the overall model. These behaviour change models could potentially be used to change the learning and study behaviours of students outside formal contact hours at a university. It is therefore argued that in order to improve attendance and usage of Mathematics Support Centres, one effective strategy may be to facilitate the formation of implementation intentions that create a link between situational cues (e.g. a specific day of the week or being at university) and the desired behaviour (i.e. using the available support).

2.1 Theories of Behaviour Change

This section aims to decompose and discuss three currently used models of behaviour change and highlight the similarities and differences of each model. Importantly the aim will be to ascertain how these models could be used to promote educational behaviour change.

2.1.1 Attitudes and Attitude Objects

Changing an individual's behaviour such that a university support service is used more frequently by him / her is more complicated than just informing a student of the services available and hoping that the right choice (from the university's perspective) is made. The way in which an individual reacts to the information is dependent not just on the perceived quality of the service but also on a body of pre-existing information that an individual already possesses about mathematics and past experiences which predispose an individual to certain behaviours. More specifically, the literature suggests that an individual's attitude towards mathematics and related entities influences whether the student will respond favourably or unfavourably to the notion of receiving extra help such as through mathematics supports centres. Qualitative data reviewed in Section 1.2.3 supports the idea of an attitude influencing students' usage of mathematical support.

This sub-section will explore and give meaning to two fundamental concepts: *attitude* and *attitude object* (where the attitude is an evaluation of some attitude object e.g. a cat or mathematical study) and importantly how the two interact with each other and other knowledge structures an individual may have. It will be argued that these constructs are context sensitive rather than 'unstable'. Even though the context sensitivity results in attitudes varying significantly, the educational literature suggests that these attitudes are important in predicting and modifying educational behaviours.

2.1.1.1 Definition of an attitude

As a starting point to understanding what an attitude may be, Bohner and Wanke (2002) suggest that an attitude object is the subject of attention (e.g. the statue of liberty) while an attitude is an individual's summary evaluation of the attitude object. Note that a summary evaluation of the attitude object is different from a summary of the attitude object. While a summary may be a reduction of the object to some subjective set of properties that are considered most important, a summary evaluation evaluates all the object’s properties (or possibly some subset of all it’s properties). The term *valence* refers to whether the attitude is positive or negative. *Magnitude* refers to the degree to which an attitude is positive or negative. *Strength* refers to the persistence of the attitude (summary evaluation) over time. It also refers to how easily an attitude is remembered and the long term recall of the mental construction.

Past literature has suggested that an attitude is composed of a number of facets that act together to evaluate an attitude object. Attitudes can be thought to be composed of Cognitive, Affective and Behavioural components (Triandis 1971, Breckler 1984) as:

- Cognitive – categorisations and relationships between categories and attributes of the attitudinal object. i.e. What it is. What is known or perceived as fact about the object…a belief.
- Affective – the feelings that are associated with the object. The feelings are the evaluative element. These act on the Cognitive component i.e. the categorisation of the object.
- Behavioural – how the subject intends to behave, these actions are directed towards the attitudinal object.

2.1.1.2 Definition of an attitude object

In Section 2.1.1.1 the attitude was introduced as an evaluative mental construct that summarised what an individual knows and feels about a particular object and more importantly how an individual should or intend to react in relation to the attitude object. The attitude object can be described as a collection of perceived facts or nodes of knowledge that together define the attitude object for the individual (analogous to the cognitive part of an attitude without an evaluative component). Objects could thus be described as mental constructs that enclose or encompass all that is known (including feelings, experiences, properties etc. similar to the affective part of attitude described in Section 2.1.1.1) about a particular “thing” in the sense of Tall and Vinner (1981) who defined an object as encapsulating all that was known about a particular mathematical idea. Another view could be a map of associations between related concepts akin to a network of interlinked ideas or nodes (Greenwald, Rudman, Nosek, Banji, Farnham and Mellott 2002). Although the literature presents many notions of what attitudes and attitude objects may consist of, what is more important is how these attitudes change and the part they play in predicting or bringing about changes in learning behaviours through appropriate interventions within Universities.

2.1.2 Theory of Planned Behaviour (TPB) and Theory of Reasoned Action (TRA)

The Theory of Planned Behaviour (Ajzen 1985) was a development of the Theory of Reasoned Action (Ajzen and Fishbein 1980, Fishbein and Ajzen 1975) which had originally been developed to distinguish between the attitude towards the attitude object and the attitude towards a behaviour involving the attitude object. Early work by Ajzen and Fishbein suggested that there was little relationship between the attitude object and very specific behavioural outcomes (Fishbein and Ajzen 1974). This was supported by earlier research that had demonstrated the poor predictive power of attitudes (LaPiere 2010, Bray 1950) in addition to later research which cast doubt on the attitudinal construct when used to predict behaviour. Fishbein and Ajzen's (1974) study (using self-report measures) looked at 100 religious behaviours of 125 university students and showed that there was no significant correlation between any individual behaviour and an attitude pairing. However, they did show that when looking at a large number of behaviours, attitudes show a high correlation with groups of behaviours which are deemed to be either positive or negative. Their study did not suggest that attitudes were of little use in predicting behaviour but rather that the measures being used to measure the behaviours may need to change.

The TPB supplements the original TRA model by adding one extra component that allows the model to take into account an individual's perception of their control over the behaviour in question. The added component expands the model to encompass behaviours that are under the control of the individual i.e. choice. The TPB suggests that the perception of control over the behaviour has a strong influence on the intention to perform the behaviour and also on the performance of the behaviour. These three components together are seen to influence an individual's intention to perform a behaviour (Ajzen et al. 2007).

Figure 2.1: Theory of Planned Behaviour

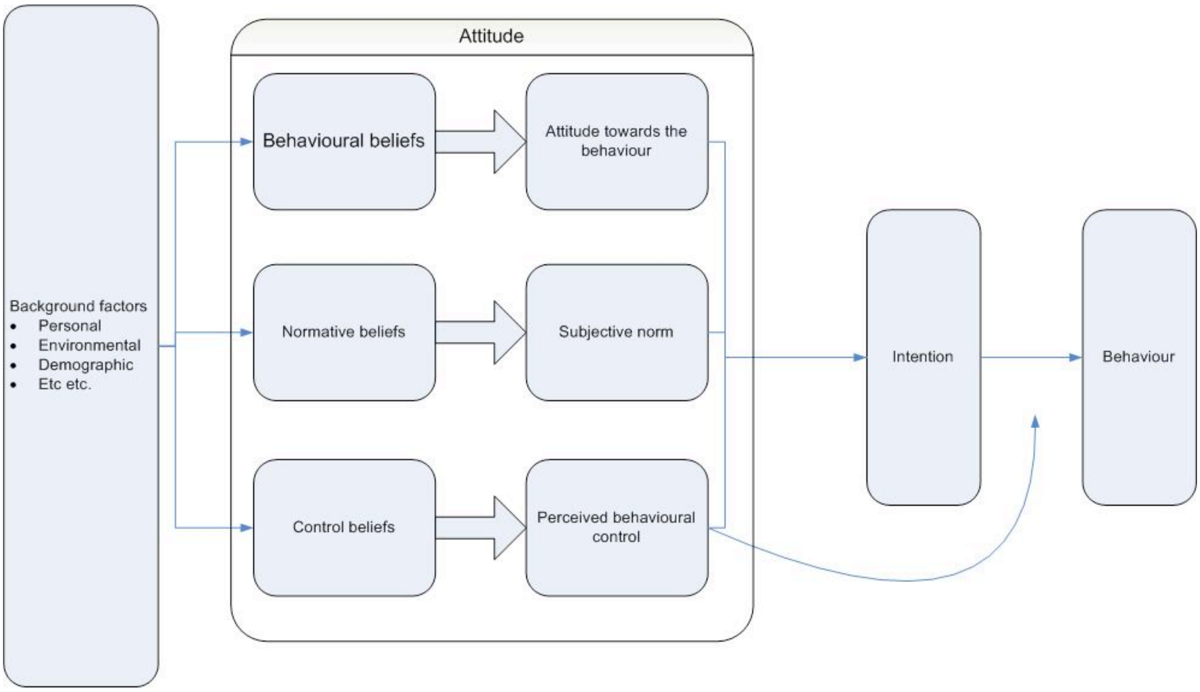


Figure 2.1 (above) shows how the TPB adds control beliefs and perceived behavioural control into the TRA. The incorporation of the control aspect is thought to better predict the intention of an individual whilst also providing more accurate predictions of actual behaviour. Each of the three components (Behavioural, Normative and Control) are summarised in more detail below, remembering that these are components of the overall attitude towards the behaviour or summary evaluation, as such each component also acts to evaluate the beliefs associated with the attitude object.

Behavioural:

- Behavioural Beliefs – composed of beliefs which describe the effects or outcomes of the performance of a behaviour
- Attitude towards the behaviour – This is the individual's own assessment of the behavioural beliefs by assessing the impact those beliefs have on the individual, the evaluation resulting in a favourable or unfavourable result for each belief.

Normative:

- Normative Beliefs – the set of perceived expectations with regards to the behaviour, is performance of the behaviour approved by other people whom the individual considers 'important'?
- Subjective Norms – This evaluation assesses the normative beliefs in relation to the individual. Again the beliefs are assessed as being positive and negative, the net effect being to either suggest that the individual should perform the behaviour or not e.g. social or peer pressures. Subjective Norms are determined by normative beliefs and an individuals motivation to comply with the expectations of 'important others'.

Control:

- Control Beliefs – Control beliefs describe facilitators or hindrances that can affect the performance or carrying out of the behaviour, possibly a mixture of internal factors such as perceived skill and external factors such as knowing that the behaviour can be performed better in the presence of A or B.
- Perceived Behavioural Control – This last evaluation assesses the control beliefs such that the resulting evaluation is a measure of how easy or difficult the performance of the behaviour is in light of the control beliefs.

It is acknowledged that many behaviours or activities that individuals indulge in could be considered eccentric, strange, unpleasant or even undesirable by important others in general. This then raises the question of why individuals persist with these activities. It is important to remember that normative beliefs are based on the approval of other people around the individual. The normative beliefs could be influenced by society as a whole or those in various sub-groups such as organisations, clubs, circle of friends and individuals. All of these sub-groups may vary in distance and importance from the individual i.e. the value of any subgroup's view or evaluation of the behaviour may be weighted differently from another group's evaluation. As a result those closest to the individual or those who share a similar interest may have their views weighted highly e.g. the student places more importance on the views of those who are taking the same course as they are compared to the views of their lecturer. However, in instances where behaviour is judged negatively by others, including those whose views are important to the individual, it is still possible to have a positive evaluation of the behaviour when related to consequences for the individual. Although the original idea of attitude (see Sections 2.1.1.1 & 2.1.1.2) was focused on an attitude object and the TPB is focused on the attitude towards a behaviour involving the attitude object there does not seem to be a considerable difference between the two when it comes to the structure as both are evaluative and the behaviour involving the object could be considered an object itself. Together, the components of the attitude construct as described by the TPB model (behavioural, normative and control) shape and influence the intention to perform a behaviour which in turn has an effect on the observable behaviour. In essence the greater the overall positive magnitude of the behavioural intention, the greater the likelihood that the individual's observed behaviour matches the intention.

Note that the level of positivity of each component is a factor of both the strength of individual evaluations of the beliefs (i.e. the longevity and persistence) combined with the evaluation of the component beliefs (i.e. the magnitude and valence). The resulting summary evaluations influence the behavioural intention. However, it is important to make note of the role that Perceived Behavioural Control has on the relationship between intention and behaviour. Of the three components, Ajzen suggests that Perceived Behavioural Control (PBC) exerts the most influence on behaviour. As a result both intention and PBC are thought to be strong indicators of behaviour. The TPB also suggests that if individuals are given the opportunity (through facilitation i.e. providing the means to perform the behaviour such as time, equipment etc.) to perform the intended action then they will tend to perform the behaviour that they initially intended.

As suggested by Ajzen, if a behavioural intention indicates that an individual would like to adopt or carry out a particular behaviour then the likelihood of this behaviour is higher than if the intention were otherwise. However, the likelihood of performing a behaviour which matches with the behavioural intention is significantly increased if the level of perceived behavioural control is high. For this to be valid an individual's estimations of their self-efficacy and external facilitators for performing the behaviour must be as accurate as possible in estimating the level of actual behavioural control (Ajzen 1991) which describes the actual rather than perceived level of the individual's skill, internal and external facilitators required for the performance of the behaviour.

In relation to the study behaviours which are the subject of this thesis, the TPB is of interest and relevance when considering the role of perceived behavioural control. The TPB model suggests that the likelihood of an individual who has intended to engage in mathematical study being able to demonstrate behaviours such as using a Mathematics Support Centre would be dependent on their perception of how well they think they could perform the behaviour. Facilitators for attending the Mathematics Support Centre would include ease of access (hours of opening, distance to building, availability of services etc.).

There are number of limitations to this model that have not been discussed so far. The model does not take into account past behaviour in the sense of forming habits. Bagozzi (1981) suggests that as the model does not incorporate past behaviours it does not have the power to explain habitual behaviours, as a behaviour is repeated it becomes a habit and the effects of evaluative components become less important. Another limitation of the model is that it does not take into account an individual's current emotional state. The TPB is limited to cognitive beliefs and evaluations of these beliefs (attitude, subjective norms, perceived control). Critics of the model have suggested that attitudes encompass more than cognitive beliefs as described by the TPB and include affective elements too (Edwards 1990, Trafimow and Sheeran 1998).

Recent studies have attempted to incorporate affective components into the model. For example, a study by Bae (2008) found that the intention of an individual to donate money was better predicted when incorporating the individual's empathy and sympathy towards the recipient of the donation than when using the TPB alone. The Theory of Planned Behaviour has been and is currently in use as a means to achieving behavioural change. A meta-analysis of 185 studies that used the TPB by Armitage and Conner (2001) suggests that as much as 39% of the variance in intended behaviour and 27% of the variance in behaviour was predicted by the TPB.

Furthermore, 31% of self-reported behaviours and 20% of observed behaviours could be accounted for through predictions made using TPB. Similarly a meta-analysis by Hagger, Chatzisarantis and Biddle (2002) looked at 72 studies that used the TPB/TRA applied to behaviours related to physical activity and found that the TPB accounted for 29% of the variance in behaviour and 50% of the variation in intended behaviour. Typical research studies involving the TPB (Stead, Tagg, MacKintosh and Eadie 2005; Hardeman et al 2002) involve a pre-post design where the TPB and other baseline measures are recorded both before and after an intervention. The intervention can take the form of exposing participants to a new information source (such as an advertising campaign, or workshops/seminars). Other interventions may involve targeting specific members of a social or family group with the aim of changing their behavior; as these groups tend to share common values and behaviours, the effects on the behaviors of other members of the group can be measured and analysed with respect to subjective norms (e.g. food eating in families with diabetes).

In summary then, the TPB presents a model for predicting, explaining and changing behaviour based on measures of self-efficacy, beliefs and social influences. By estimating intention and the level of perceived behavioural control a prediction of the actual behaviour can be made. However, the model does not attempt to fully explain how an intention can be turned into behaviour. In addition, the role of the TPB in relation to behaviours such as habits and addictions is lacking. This model is a static structure although changes in one part of the structure can ripple through and affect other parts e.g. if an individuals personal situation changes this may result in the control beliefs changing thereby influencing PBC which in turn affects the intention to perform a given behaviour. It is important to note that the model is better at predicting intentions than actual behaviours. Some recent literature has also highlighted that the model omits affective components and as such limits the predictive power of the model. It has also been stated that the Theory of Planned Behaviour does not take into account the potentially diminished effect of summary evaluations after behaviour has occurred a number of times previously. From the evaluation of the usage of mathematics support services within a university context (see Chapter 1) it is suggested that these behaviours tend to become habitual. Students who make use of the services tend to do so on a regular basis. The model also does not make any attempt to explain how an individual makes the transition from intention to behaviour. In the next section a stage-based model is described that attempts to both explain how an individual makes the transition from intention to behaviour and also how this new behaviour is maintained.

2.1.3 Transtheoretical model of behaviour change (TTM)

The Transtheoretical model of behaviour change or TTM (Prochaska and DiClemente 1992) suggests that the process of behaviour change is a transition through a number of stages. This transition through the stages begins with the individual in an equilibrium state where there is no perceived need or desire to change through to post behaviour change where the goal is to maintain the new behaviour and prevent a reversion into the old behaviour. The five stages suggested by the TTM are briefly outlined below:

Pre-contemplation – This phase is associated with the individual not having an inclination to change their current behaviour, during this phase they do not perceive any need to change their current patterns of behaviour (within the next 6 months).

Contemplation – those individuals identified as being in the contemplation phase have decided that they wish to make a modification to their current behaviour within the next 6 months (i.e. the behaviour in the Pre-contemplation phase). However, although they are aware they wish to make the change, their attitudes towards the behaviour are ambivalent (Bleuler 1950); that is to say bipolar in a sense and conflicting. These attitudes are based upon ideas associated with the beliefs (beliefs, norms and controls from the TPB) that are evaluated as being beneficial/ positive. However during this phase the negative consequences of performing or adopting this behaviour are weighted highly and are very important in the decision to either perform or refrain from carrying out the behaviour (Prochaska and DiClemente 1992).

Preparation – This phase marks the beginning of an individual’s decision to make changes to their behaviour. During this phase the individual intends to make some modifications to their original behaviour in the near future (within 30 days). However, although the intention may be there and some rudimentary ideas on how the individual may attempt to change their behaviour may have formed, no behaviour change has actually occurred.

Action – At this point the individual has been able to make the transition from thinking about the performance of the new/modified behaviour to an actual/observable change which deviates from the original behaviour. At this stage the individual’s behaviour can be observed to have changed. However, this behaviour has only been observed for a short length of time (less than 6 months). Although the behaviour is new and different from the observed behaviour which occurred in the pre-contemplation phase there is no real evidence at this early stage that the observed behaviour is indicative of long term behaviour change.

Maintenance – The last phase occurs after the individual has changed their observable actions and behaviours (more than 6 months). Performance of the behaviour initially may be achievable, however, the individual then needs to consciously maintain that behaviour and try to ensure that relapse to the old behaviour does not occur.

Lastly once the change of behaviour is complete the new behaviour becomes the norm. In essence the behaviour is no longer regarded as target behaviour, but rather the normal behaviour that the individual is accustomed to. In this sense the individual is back at the pre-contemplation phase with the new behaviour having taken the place of the old behaviour, and the need to adopt a new behaviour or the requirement to move from one phase to another phase is no longer present. Typical interventions based on the TTM would first involve the identification of the stage at which the participants were located. Once the stage was identified a stage specific intervention would be administered to initiate a transition to a subsequent stage. Stage specific interventions could be to aid an individual to realise that they need to change their behaviour (pre-contemplation to contemplation) through education followed by self-evaluation. Action to maintenance could be facilitated through supportive strategies aimed at supporting the individual with their new behaviour e.g. support groups or meetings with others who are maintaining that behaviour (such as quitting smoking).

A meta-analysis by Marshall and Biddle (2001) of 71 studies examining the TTM suggests that there is some evidence to support the use of the model and that interventions used in the studies that were examined did to some degree show a movement or change in stage that was consistent with the TTM model. However, they also highlight that the majority of the studies that were examined were of a cross-sectional design, and as a result they were poorly suited to examine and provide evidence for a multi-stage model such as the TTM. Another meta-analysis by

Hutchison, Breckon and Johnston (2008) looked at 24 studies related to physical activity and how interventions based on the model were applied. Of major concern to Hutchinson et al. (2008) was how the majority of studies failed to use an intervention that was truly representative of the TTM model. Interventions deemed to be unrepresentative were those where the study looked at only one variable i.e. the stage the participants were in before and after interventions. A meta-analysis by Bridle, Riemsma, Pattenden, Sowden, Mather, Watt and Walker (2005) supports this by suggesting that part of the problem with many interventions and studies can be traced back to a lack of a precise definition of the stage based TTM and how it applies to each individual study. Furthermore, Bridle at al. (2005) goes on to suggest that this lack of precision in the model (such as hurdles to making the transition from one stage to the next and the exact process of moving from one stage to the next) could have led researchers to create inappropriate or ineffective interventions.

As a result they suggest that future research involving interventions that better address the model would allow analysis to be carried out to assess the effectiveness of the TTM model. However, Littell and Girvin (2002) carried out a meta-analysis of 87 studies and suggest that the evidence indicates that individuals do not go through stages sequentially. Littell and Girvin's interpretation of their findings suggest that there is little evidence to support the TTM as being a multistage model and that individuals could be in multiple stages at the same time. Their interpretation implies a continuous model of behaviour change rather than a staged model better explains the empirical data.

The TTM model suggests that changes in behaviour occur as a result of transitions through a number of stages. The literature suggests that the exact duration an individual stays in any particular stage is highly variable and is dependent on the context. The time taken to make a transition from one stage to the next is unclear. Initial stages involve the individual becoming aware of the need for a change in behaviours while latter stages focus on overt changes in behaviour and the maintenance of those behaviours. In a learning context such as the use of Mathematics Support Centres, students would initially need to identify a need or a reason to change (contemplation) followed by intention to use the support services (preparation). From this point they could make use of the Mathematics Support Centres (action) and ideally keep using the service in the long term (maintenance). The TTM model seems a useful model for trying to describe and change study behaviours as it attempts to describe the process of change from pre-contemplation/contemplation stages (becoming aware that a change needs to be made) to the action stage where the behaviour has been carried out. The model also takes into account past behaviours and the need for the individual to maintain this behaviour through conscious effort that the TPB did not use. What is still an issue with this model is the transition from the preparation to the action phase. The literature is still unclear on how this transition occurs and the processes involved. Where this model may be better than the TPB is its attempt at addressing the importance of maintenance, past behaviour and relapse. The model does appear to have merit in attempting to predict behaviour. However, as Bridle et al. (2005) and Hutchinson, Breckon and Johnston (2008) have highlighted, research to date has not been able to correctly test the model due to flawed interventions and experimental designs. Marshall and Biddle (2001) highlight how many studies employing the TTM have used a cross sectional rather than a longitudinal design which seems incorrect given that individuals would move between stages over time. Furthermore, literature has suggested that due to the flawed experimental designs and inconsistent interpretation of the TTM, experimental results do not necessarily suggest that only a multi-stage model could explain the results. It is difficult to assess if this is a good model or not in light of this. Both the TTM and the TPB suggest that an individual's behaviour can to some extent be predicted by an individual's intention to perform the behaviour. However, how the process of moving from intention to behaviour works is unclear. The formation of habits suggests that a positive attitude or summary evaluation is not always important during the process of carrying out a behaviour (Bagozzi 1981: 625). According to the TPB the individual's perception of being able to perform the behaviour can determine how likely an intention can be turned into a behaviour. In the next section an intervention model for behaviour change will be described that attempts to provide some explanation of how an individual may move from the preparation to action stages (or turn an intention into a behaviour).

2.1.4 Goal intentions and implementation intentions (II)

The Theory of Planned Behaviour has been shown to be good at predicting the intentions of individuals based on the attitudes of the individual towards an attitude object (see Section 2.1.2). Both the TPB and the TTM (Section 2.1.3) suggest that a precursor to behavior change is the intention to change the current behavior. Neither theory provides a mechanism by which the individual turns an intention into a behavior. One theory aims to address this shortcoming through the use of mediating constructs called implementation intentions. implementation intentions (Gollwitzer 1999) suggest a mechanism though which an intention can become a behaviour and can also help explain why not all intentions lead to observed behaviour. Research by Webb and Sheeran (2007) and Gollwitzer (1999) suggest models of behaviour change that focus on cue accessibility and use this as a means of promoting goal-directed behaviours. Cue accessibility refers to the mind being able to recognize a situational cue and potentially act on it. Increasing cue accessibility means that the mental representation of a pre-determined situation or cue (e.g. a time of day, a location, a person) becomes highly activated. Increasing the cue accessibility makes that representation easier to access. The result is that the implementation intention increases an individual's ability to recognize the cue and then respond with a pre-determined action; hence aiding the ability to carry out a goal directed behavior. Implementation intentions are short statements or plans constructed by an individual that link a specific situational cue to a desired action or behaviour (If X then Y), for example "If it is Tuesday then I will go to the gym after work".

Although these plans are quite simplistic, there is a growing body of evidence that suggests that when individuals consciously form these statements, either in writing or by reciting the statements verbally, they are far more likely to follow through with their intended behaviours. However, it should be noted that during the performance of the actual behaviour the individual does not necessarily consciously think about the conditional statement described by the implementation intention. It is important to note that the behaviour described in the plan may be just a small step towards a greater goal in the sense that a goal intention is a goal that the individual would like to achieve i.e. “I want to Z” and can be very general (e.g. where Z could be improve my mathematics or pass a mathematics exam). For example, Casper (2008) carried out an experiment to change the method of teaching amongst mental health practitioners (*N* = 78). Participants attended one of two versions of a class (1 session lasting 6 hours) on psychiatric advance directives, one class facilitated the formation of implementation intentions (*N* = 40) while the other did not (*N* = 38). The implementation intentions that were formed by participants identified when and where to carry out a practitioner guided procedure. The use of the practitioner-guided procedure was measured using self-report questionnaires three months after the intervention. The results of the study found that there was no statistically significant difference in the intentions of participants from the two conditions. It was found that those who had formed implementation intentions (80% of the treatment group) were more able to use the new teaching method than those who had not (58% of the control group). However, the results also suggested that there was no statistically significant difference in the use of practitioner-guided procedures between participants who had the highest level of intentions. The study used self-report measures that are inherently less reliable than observations. Furthermore, the experiment did not measure the participants' pre-intervention behaviours; this omission could have led to incorrectly over or underestimating the effects of implementation intentions if there were differences between the two groups at baseline.

An experiment by Webb and Sheeran (2007) looked at the speed at which participants were able to respond to a task aimed at identifying four words and four non-words in a word search problem. The participants who were UK undergraduate students (*N* = 74) were allocated to one of two conditions. Those in the first condition were given instructions that asked them to familiarise themselves with one word (avenda) while those in the second condition were given instructions that allowed the students to form implementation intentions. All participants completed the experiment by using a computer and following the instructions presented on the screen. It was found that those who had formed implementation intentions were able to respond quicker as they were able to identify situations or opportunities to act. The increase in speed did not have an impact on the accuracy of their responses.

Implementation intentions were also shown to mediate the gap between goal intentions and actual behaviour in the context of job seeking (van Hooft et al. 2005).

However, this study did not try to change or create implementation intentions of the participants but rather analyse their pre-existing ones and those that form whilst engaged in their job seeking process. Interestingly the results of van Hooft et al. did not suggest that procrastination inhibited the ability of individuals to engage in job seeking activities. Furthermore, it was suggested that those who had high levels of self-efficacy and perceived the job seeking process to be under their control were more likely to form implementation intentions related to job search activities.

Similarly, a study by Luszczynska (2006) looked at the exercise behaviours of patients (*N* = 114) after a Myocardial Infraction (MI) incident. Levels of physical activity were monitored at three points during the study, a week after the MI incident, 8 weeks after the MI incident and a short 2 week rehabilitation course consisting of a cardiovascular exercise program and finally at 8 months after the MI. After the second data collection point participants were allocated to either the control (*N* = 55) or treatment (*N* = 59) conditions. Those in the treatment conditions were shown how to create implementation intentions that described the types of exercises to be performed together with the time and location of where the behaviours were to be performed. Measures of exercise behaviours were obtained through self-report question items on a questionnaire. The results of the study suggested that those who had formed implementation intentions were far more likely to continue their exercise activities (3 or more times a week) 8 months after the MI incident than those who had not. The use of planning strategies was also found to correlate with the amount of physical activity for those in the treatment condition (*r* = 0.59, $p < 0.001$).

Furthermore, a study by Webb, Christian and Armitage (2007) examined how implementation intentions could be used to improve the class attendance of undergraduate psychology students (*N* = 100). Participants who were 85% female were randomly allocated to either the control (*N* = 53) or treatment (*N* = 47) conditions. The study looked at the TPB constructs and personality measures alongside class attendance. The implementation intention intervention consisted of a questionnaire with guidance for how to construct implementation intentions, once constructed the instructions required the participants to write out their plans. The guidance for forming implementation intentions was not provided for questionnaires completed by those in the control condition. The results of the study suggest that class attendance can be significantly improved by the construction of implementation intentions (attendance in the treatment group was 83%, compared to 69% in the control group). Furthermore, the study also found a statistically significant interaction between conscientiousness and the condition. Those in the treatment condition with low to moderate levels of conscientiousness showed the greatest benefit from the intervention compared to those with high levels of conscientiousness.

Recent meta-analyses (Gollwitzer and Sheeran 2006, Webb and Sheeran 2006) support the idea that the use of implementation intentions is beneficial in facilitating goal directed behaviours. Gollwitzer and Sheeran observed medium to large effect sizes (d = 0.65) from the 94 studies that were included in the analysis. However, Meeks and Marsh (2007) conducted a study where 311 people were tested across three conditions; two conditions used non-focal cues in the implementation intentions (a general cue that is not specific i.e. an animal), while the last involved a specific focal cue (a specific cue i.e. giraffe or tiger). Their results suggested that both non-focal and focal cues seemed to produce the beneficial effects. They go on to suggest that if both types of cue work using an identical mechanism then it is unlikely to be a result of increased cue accessibility or a bond formed between the cue and desired response.

It should be noted that although the studies above suggest that implementation intentions are beneficial for individuals in accomplishing goal directed behaviours there are other studies that suggest some caution in the application of implementation intentions. A study by Powers, Koestner and Topciu (2005) looked at how well individuals were able to adhere to New Year resolutions after formulating implementation intentions. The results of the study suggest that individuals who can be described as socially prescribed perfectionists (individuals believe that they must be perfect or close to perfect for society to value them) and those who are highly self-critical were less able to perform their goal directed behaviours after the formation of implementation intentions.

The studies described in this section suggest that implementation intentions can be useful in increasing the performance of desirable behaviours. Students who have areas of mathematics that need development may benefit from the use of an intervention based on implementation intentions. Students who require assistance could find implementation intentions a potentially effective strategy for helping them to engage with the mathematics support provision on offer (through increased usage).

2.2 DECONSTRUCTION OF THE THEORIES OF BEHAVIOUR CHANGE

This section aims to examine the theories of behaviour change discussed in Section 2.1 by decomposing them into their component processes, and by doing so allow a critical evaluation of the theories as tools for changing educational behaviours. Theories of behaviour change can be grouped into either dynamic or static types. Dynamic types are where an individual is described as moving through a number of stages (e.g. Transtheoretical model of behaviour change). Static types are those models where a network of interrelated mental constructs exist simultaneously, changes in one construct can propagate and initiate changes in other related constructs (e.g. Theory of Planned Behaviour). A decomposition of the three models of behaviour change is shown in Table 2.1 (below).

Table 2.1: Decomposition of the theories of behaviour change and implementation intentions

Theory of Planned Behaviour (TPB) *Static model*	Transtheoretical model of behaviour change (TTM) *Dynamic model*	implementation intention (II)	General Concept
Behavioural Belief -> Attitude towards Behaviour	Pre-contemplation	Attitudes used to inform Goal intentions	Attitude
Normative Beliefs -> Subjective Norm	Contemplation		
Control beliefs -> Perceived Behavioural Control			
Intention	Preparation	Goal intention	Intention
Perceived Behavioural Control		implementation intention	
Behaviour	Action	Goal directed behaviours	Behaviour
	Maintenance		

A decomposition and categorisation (static or dynamic) as shown above could also be carried out on other theories of behaviour change such as the Elaboration Likelihood Model (Petty and Cacioppo 1983, 1986) and Self-Determination Theory (Deci and Ryan 1985b, Deci and Ryan 2000, 2002, Ryan and Deci 2000a, 2000b). The above theories were not included in the review as they are all examples of either static or dynamic models. It was decided to pick an example of each type of model as a representation of the wider body of theories that currently exist for changing behaviour; furthermore, these models formed the basis of more recent models such as self-determination theory. The decomposition of the theories shown in Table 2.1 suggests that there are similarities between the constituent components of the models. Each model appears to consist of three main types of components i.e. attitude, intentions and behaviours. Each model includes some form of mental construct that defines the way an individual feels or evaluates the current state (e.g. pre-contemplation and contemplation in the TTM). The models also include a stage or component where the individual has decided to make a change in their own behaviour (e.g. intention in the TPB). The last type is the actual behaviour of the individual. What the models do generally fail to adequately describe is the process through which an individual makes the transition from an intention to a behaviour. The remainder of this section will discuss the underlying properties that these components represent whilst also highlighting areas not included in the models.

2.2.1 Attitude

An examination of Table 2.1 indicates that the first two models of behaviour change (TPB and TTM) tend to incorporate an evaluative component analogous to an attitude. Within the Theory of Planned Behaviour the attitude component was composed of Attitudes Towards the Behaviour, Subjective Norms and Perceived Behavioural Control. Within the Transtheoretical model of behaviour change (TTM), two components (first two stages within the model) seem most similar to what is defined as an attitude. The pre-contemplation phase and contemplation together are analogous to the formation of an attitude through the negative and positive consequences of adopting a behaviour being evaluated. The pre-contemplation phase as described in Section 2.1.3 is a stage where there is no perceived need to change a behaviour, similar to the static model of the Theory of Planned Behaviour before a change in attitude occurs. Implementation intentions sit between an Intention and behaviour. Importantly the Intention to perform a behaviour is informed by the attitude towards the behaviour. However, other mental constructs that the attitude could be informed by e.g. the attitude object and past actions seem to be less important in the model as a whole. Attitudes as described in Section 2.1.1.1 are constructs that encompass a wide range of information based on facts, beliefs and social evaluations of the behaviour. The scope of the information that is used to form the attitude and also the scope of the attitude is difficult to define. As Triandis (1971) and Breckler (1984) have suggested, attitudes can encompass cognitive, affective and behavioural components while the Theory of Planned Behaviour suggests attitudes encompass attitudes towards the behaviour, what society feels about the behaviour as well as perceptions of control. The information in these attitudes could be drawn from any part of an individual's experiences occurring at any time of their life. As a result this can lead to difficulties in the measurement of attitudes along with attributing or identifying correctly which attitudes are important. Attitudes would seem to appear to be important in gauging individual's potential educational behaviours i.e. the use of university support mechanisms such as the Mathematics Support Centre. However, these factors have not been adequately researched in the educational literature. The next section discusses this issue in more detail.

2.2.1.1 Attitudes in Education

The educational literature suggests that the study of attitudes can give insight into how students approach the learning of mathematics. Macrae et al. (2001) highlight how little research has been done with regard to attitudes of Higher Education students in England. Skemp (1976) has suggested that students' learning of mathematics (either relational or instrumental) was strongly influenced by their personal attitudes towards mathematics. Recent empirical research has suggested that approaches to learning are influenced by individual's attitudes towards mathematics. A study by Crawford, Gordon, Nicholas and Prosser (1994) used a questionnaire to gather data from approximately 300 1st year undergraduate students and explored students' attitudes towards mathematics and their approaches to learning and studying mathematics. Their results suggested that the majority of students felt that mathematics was mostly about learning a set of rules. Furthermore, Crawford, Gordon, Nicholas and Prosser (1998) used two questionnaires to explore undergraduate student conceptions of mathematics and approaches to learning mathematics. The questionnaires were administered at the start of the first year of study and also at the end of the first semester. Their results suggest a relationship between perceptions and attitudes of mathematics and the approach taken to learning mathematics. Those who felt mathematics was an exercise in learning a set of rules also approached their learning in a rote fashion.

Furthermore, Shaw and Shaw (1997) identified that A-level grades alone were not sufficient to predict students' achievement and performance at degree level. Their study used questionnaires to gather data on attitudes towards mathematics and also difficulties with mathematics from 139 1st year computer engineering students. 83% felt they would like to improve some aspects of their mathematical competencies while only 31% enjoyed the mathematics component of the course. The study by Shaw and Shaw also used cluster analysis to identify five types of students (High-Flyers, Downhillers, Haters, Ambivalents and Realistics). They found that attitudes towards mathematics were significantly different between the groups and could be used as a way to help inform targeted support for students with mathematical difficulties. The three studies suggest how important an individual's attitude towards mathematics is, not just for engagement with the subject, but also for the strategies used for learning mathematics. A study by Ablard and Mills (1996) looked at 153 academically able adolescent children and used self report instruments to gather data on self-perceived measures of their own ability, effort (towards learning) and perceptions of intelligence (fixed or changeable). They found 9% of the participants to be at risk of underachievement despite their academic performance to date; they believed that they were less able than their peers and also that intelligence was 'stable' in the sense that it could not be improved through hard work. Students may have a personal view (perception or misconception) of intelligence that it is either genetically pre-determined or it is acquired as a result of prolonged study (Dweck 1999). This suggests that some students may not have engaged with support mechanisms if they believed achievement in mathematics was beyond their reach because they have not been born with innate mathematical ability and consequently no amount of extra work would likely improve their ability.

In Sections 2.1.1.1 and 2.1.1.2 the mental constructs of attitude object and attitudes were discussed, and it was suggested that these constructs inform an individual's intention to perform a behaviour. Research suggests that the accessibility of memories and objects (sometimes conflicting) are often context dependent, resulting in different strategies (not always correct) used to tackle identical mathematics problems in different contexts (Boaler 1993, Nunes 1993, Mevarech 1997). This is similar to the context dependence of attitudes (Schwartz 2007) that can lead to conflicting attitudes or cognitive dissonance (Festinger 1956, 1957). This suggests that attitudes are context dependent and that conflicting behaviour can occur when conflicting attitudes or intentions are evoked simultaneously. In the context of education and study behaviours, this finding suggests that students could have good attitudes and intentions towards studying outside of lectures while sitting in the lecture theatre but when outside of the formal learning environment could have a negative attitude towards mathematics study and not wish to make use of the support services. Based on the research described above, it is suggested that attitudes that inform intentions and subsequently behaviour may be poor predictors of behaviour when the context has changed.

The influence of context on behaviour is also evident in the way individuals approach mathematical problems. Nunes (1993) conducted several studies that looked at how children performed arithmetic problems in different contexts. Her findings suggested that when the children were in formal school settings they implemented school taught strategies to solving mathematics problems with a mixture of success. However, when the children were working as street vendors, calculations were performed more successfully through the use of strategies not necessarily taught at school. Furthermore, a study by Little and Jones (2010) looked at 594 students aged between 17 and 18 years and suggested that contextualisation of questions can add complexity and unnecessary distractions to questions. However, as Nunes (1993) and Boaler (1993) have shown, contextualisation can have an effect on the strategies used to solve the problems as the students can draw on their past knowledge of the context to help inform or select appropriate strategies for solving the problem. These strategies are not always coherent with other strategies. However as they are not all evoked or accessible at the same time they do not cause cognitive conflict (e.g. street mathematics strategies being different from those used in a school context). It is suggested that the same is true for learning strategies and that individuals can be adept learners in one context yet may appear lazy or apathetic in others. To the individual there seems no discernible contradiction in their different attitudes to learning yet an observer may easily see that there is. The above literature supports the idea that mental objects are context sensitive and that changing contexts (be they environmental, those from a mathematics problem, or learning situations) can evoke different attitudes and intentions. Though the literature has discussed the importance of context, it is unclear whether any of the studies had addressed the concept of habit formation in reinforcing the behaviours or strategies observed.

Attitudes, intentions and behaviours have been suggested as being contextually sensitive. The contextual sensitivity described above could explain why the literature suggests that attitudes do not accurately predict behaviour. The literature (Fishbein and Ajzen 1975, Macrae 2001) suggests that the study of attitudes would be useful in predicting and changing students study behaviours. Some research would suggest that while individuals with strong attitudes do behave in the predicted manner (Holland et al. 2002), it is possible for an individual's attitude to be changed or influenced by their own behaviour. However, other research (e.g. Wicker 1969, Ajzen et al. 2007) highlights how even though attitudes are good predictors of intention, they do not explain all of the differences between the intended behaviour and actual behaviour. Though the contextual sensitivity seems to explain why there may be some discrepancy between intended behaviour and actual behaviour, it does not explain how an individual turns an intended behaviour into an actual behaviour.

The evidence so far suggests that attitudes are good at predicting intentions but less so for predicting actual behaviours. Furthermore, it has been highlighted that the discrepancy between intention and behaviour could be due to the contextual dependence of attitudes and intentions. The lack of evidence for the effectiveness of attitudes used for behaviour prediction combined with the difficulties associated with the measurement of attitudes (e.g. context dependence) indicates that the use of this construct for improving the study habits of students may be difficult and possibly ineffective. Educational research on behaviour change has regarded attitude constructs as important. Many studies have not found attitudes to be reliably linked to successful behavioural change (e.g. Wicker 1969, Ajzen et al. 2007). However, intentions are suggested to be the construct immediately preceding the contextually dependent attitude construct. A further discussion of this construct is given in Section 2.2.3.

2.2.2 Intention

Each model describes a construct that serves the purpose of an intention. An intention is a construct that defines how an individual would prefer to behave in a given context. Within the models represented in Table 2.1 this construct is shown as an intention (Theory of Planned Behaviour) and Preparation stage (Transtheoretical model of behaviour change). The Preparation stage (Transtheoretical model of behaviour change) suggests that the individual has made the decision to change their behaviour but as yet has made no observable change (Prochaska and DiClemente 1992). Similarly the Goal Intentions as referred to by implementation intentions are intentions to perform goal directed behaviours. However, Goal Intentions are only intentions and as such may or may not be realised as observable behaviours. The intention construct is based upon the constructs that are analogous to attitudes (Section 2.2.2). In both the dynamic and static types of model the intention indicates how an individual perceives himself or herself acting in a given situation. Conner and Norman (2005) suggest that during the pre-contemplation phase in the TTM model the individual has no awareness of the need to change their own behaviour. They suggest that the intention to make a change in their behaviour only occurs at the preparation stage. Prior to the preparation stage, an individual is either unaware of a need to change their behaviour or is deciding if a change is necessary. As with attitudes, this construct is measured through self-report or interviews. Importantly, as these data are based upon an individual's perception of his or herself, they may not be an accurate measure of an actual behaviour. However, unlike the attitude construct, which is not easily definable (i.e. what are the important parts which are influencing the intention), intentions are easier to measure with questions focusing on specific learning behaviours. Questions such as, "How many hours do you think you will study mathematics over the next week?" or "Do you plan to use the Mathematics Support Centre this coming month?" are both examples of questions that explore the intention to perform a learning-related behaviour. The intention to perform a behaviour is informed by the attitude construct. However, the intention is more specific and indicates what the individual would want to do. The intention construct is important as all the models suggest it precedes the actual performance of the behaviour. What the TPB and the TTM models do not give insight on is the process through which an individual moves from an intention to a behaviour.

2.2.3 Behaviour

As all the theories of behaviour change aim to either explain behaviour or inform interventions that could change behaviour, each model contains a component that defines the actual behaviour of an individual. In the models described earlier these are explained as Behaviour (Theory of Planned Behaviour), Action (Transtheoretical model of behaviour change) and Goal directed behaviours (implementation intentions). Each of these relate to the actual behaviour of an individual and may not necessarily be in line with the internally constructed construct of intention. Models such as the Transtheoretical model of behaviour change have a post-behaviour component called Maintenance. The Maintenance stage describes how the new behaviour is maintained once it has been performed for the first time. The behaviour in the models discussed in Table 2.1 are always post intention and occur after the individual has made a conscious decision to change their behaviour. In both the static (TPB, Ajzen 1985) and dynamic (TTM, Prochaska and DiClemente 1992) models there is no clear indication of the exact processes through which an individual moves from an intention (Section 2.2.3) to a behaviour. The behaviour is easily measured through observation or self-report questionnaires.

2.2.4 Motivation

In addition to the Attitude construct that is present in some form in most models of behaviour change, Motivation has also been described as being one factor which plays a role in determining an individual's behaviour; more importantly it also explores the 'why'. Where the 'why' refers to the reason or push to change or adhere to a particular type of action. This push or pressure to change or remain unchanged (validating original behaviour) is important for both initiating a new behaviour and for self-regulation and motivation (Deci and Ryan 1985a, 1985b). Motivation can range from intrinsic to extrinsic and be based on social pressures, external rules or a wish for self-improvement regardless of external perceptions (examples include enjoyment, a desire to help others and love). For example the Theory of Planned Behaviour (Ajzen et al. 2007) splits up the attitude construct into 3 different categories, each category contains (or is an association) certain types of beliefs (*behavioural beliefs*, *normative beliefs* and *control beliefs*) which are thought of as being true by a particular individual. These then lead to 3 corresponding summary evaluations (*Attitude Towards Behaviour*, *Subjective Norm* and *Perceived Behavioural Control*). Interestingly two components of the attitude as described by the TPB and the TRA are also suggestive of being described as motivations (Sheppard, Hartwick and Warshaw 1988):

- Behavioural (Attitude towards the behaviour) – Could be interpreted as an evaluation of how the outcome of performance of the behaviour impacts directly on the individual (based on the beliefs the individual holds) akin to intrinsic motivation.
- Normative (Subjective Norm) – Could be interpreted as an evaluation which expresses the degree to which social attitudes and expectations result in pressures, forces or 'extrinsic motivators' which suggest how an individual should behave.

The TTM also includes motivation in the contemplation and preparations stages of the model where the individual has decided that a change in behaviour is needed but has yet to act on it. It has been argued by Smith (2004: 95) that universities need to accommodate to the needs and requirements of current GCE students. At the heart of the "accommodation" is a need to encourage students to engage in mathematical study actively, either on their own, with their peers, or by taking advantage of support offered by the university. For this to happen, most students need to change their study behaviours. For students to change their behaviours there needs to be some form of motivation either extrinsic or intrinsic such that individuals will change their intended study behaviours.

The Theory of Planned Behaviour built upon the Theory of Reasoned Action (Ajzen and Fishbein 1980, Fishbein and Ajzen 1975) by suggesting that an individual's perception of how easy or difficult it would be to perform a behaviour plays a significant factor in the resulting congruence (or not as the case may be) between intention and behaviour. Bandura (1977) suggests that one major factor when determining the extent to which an individual performs certain behaviours is the type of expectations the individual has about performing the behaviour. However, expectations are not solely related to the results of the performance of the behaviour i.e. what is to be gained or lost or how the performance is either incremental or detrimental to the situation the individual finds themself in. Bandura (1977) suggests two forms of expectancy:

- Outcome expectancy - this expectancy relates to what the individual believes to be outcomes which result from the performance of the behaviour

- Self-efficacy – is the perception or belief of how easily an individual feels that a behaviour can be performed or an individual's perception of how well they are able to carry out a particular behaviour or task.

The two forms of expectancy described above suggest that the evaluation of performing the behaviour could be a source of motivation if an individual believes that performance of the behaviour is beneficial and also if the individual believes that performance of the behaviour is feasible. The extra component relating to control suggested by the TPB, in addition to the self-efficacy component of Bandura's expectancy model (Bandura 1986, Bandura 1994) suggest that the perception of how easy it is to perform a task or engage with it is significant in the prediction of behaviours. Research on the TPB has suggested that the impact of control beliefs is significantly higher than that of the motivations generated by the *behavioural beliefs* and *normative beliefs.* Both the Theory of Planned Behaviour and the Bandura's expectancy model suggest that an individual's ability to gauge how easy a behaviour is to perform plays a significant role in predicting as well as influencing behaviour and is discussed in the next section.

2.2.5 Control

A number of models of behaviour change make reference to perceptions of control. In Section 2.2.4 the expectancy model suggested by Bandura (1986, 1984) indicated that an individual's assessment of how easy a behaviour would be to perform was important in being able to predict and influence future behaviour. Similarly, the Theory of Planned Behaviour (Section 2.1.2 and Table 2.1) suggests that the level of Perceived Behavioural Control can influence how well an individual's actual behaviour is in line with their intentions. Implementation intentions (Section 2.1.4) suggested a strategy for changing behaviours through the formation of implementation intentions, these statements or expressions linked a goal-directed behaviour with some external cue. It would seem that implementation intentions build upon the Perceived Behavioural Control component of the Theory of Planned Behaviour as suggested by Webb and Sheeran (2008, Study 1). The formation of implementation intentions requires the individual to identify a time (or place) where the goal directed behaviour could be performed. Through this plan formation the individual has had to mentally create or identify a realistic scenario where the behaviour could take place. Importantly this process could allow for increased levels of Perceived Behavioural Control as the formation of the implementation intention required the individual to explicitly identify and acknowledge that the behaviour could be carried out.

If it is assumed that first the individual is motivated to perform behaviour X (either through extrinsic or intrinsic motivations) and in addition 'perceives' that the performance of X is feasible using the available physical and mental resources, it would seem that there is a high chance that the intention to perform a behaviour could be translated into a real action. However, a problem occurs when the perception of control does not match up with the actual ability to perform the behaviour (i.e. lacking the physical tools/ mental capabilities/ in the wrong location) i.e. where Actual Behavioural Control is less than the perceived behavioural control. The literature on study behaviours and use of Mathematics Support Centres (see Sections 1.2 and 1.2.3) have generally focused on the number of students who have used the services, self reported measures of effectiveness and yearly attainment of students in general. From literature on educational behaviours and in particular study behaviours the aspect of control has not been examined. Control would appear to be an important aspect in the TPB and also for implementation intentions (II) as those constructs aim to help explain how individuals move from an intention to a behaviour.

2.3 Link between Intention and Behaviour

The models described in Section 2.1 all attempt to describe how changes in attitude can subsequently change behaviour. Each theory describes a process by which an individual goes from one state of 'equilibrium' where they have no intention to change through to a state where their personal intentions based on their attitudes towards the behaviour have changed such that they intend to act differently. A deconstruction of three theories and models of behaviour change (Section 2.2) suggests many commonalities in the attitude and intention constructs. Furthermore, Section 2.2 also suggests that while there is plenty of detail describing the process of intention formation, there is little explanation of how an individual acts upon an intention such that it becomes an observable behaviour. However, it would appear that models such as the Theory of Planned Behaviour (Ajzen et al. 2007) are satisfactory at predicting intention, but in isolation are not very good at predicting behaviour (Sniehotta et al. 2005). Empirical research (Kirner et al. 2006) also highlighted that intentions and actual behaviours are not in all cases the same. Given this observation it seems that trying to base predictions of future behaviour or trying to influence future behaviour by looking at (or modifying) solely the attitude towards the behaviour may be possible yet inaccurate. However, from the discussion earlier in this chapter it is apparent that attitudes towards both the attitude object and the behaviours involving the attitude object are important influences on the intention of the individual but not necessarily the final performance of the individual.

Together, attitudes and attitude objects are unable to explain completely the observed behaviours of individuals and as such it would then seem sensible to look for other factors which may be influential in determining how an individual actually behaves. This is supported by recent research (Gollwitzer 1999, Webb and Sheeran 2007) which has identified that although the prediction of the intentions can be highly accurate and indicate to some degree the possible behaviour of an individual; predictions of observed behaviours may be less accurate (Sheeran 2002). For example, if an individual was highly enthusiastic towards the idea of increasing the time they spend studying then it would seem sensible that the individual may have strong intentions to study and consequently a higher chance of realising that goal than an individual who was somewhat less enthusiastic. However, there is the problem that the intentions do not always predict the behaviour of an individual and as such an individual being highly enthusiastic and with good intentions about studying does not necessarily imply that they will study more.

Recent research has also hinted at how the effectiveness of individuals in being able to accomplish certain behaviours may be influenced by their personality (Song et al 2006). Furthermore, Webb, Christian and Armitage's (2007) suggested that while implementation intentions were effective in changing behaviour, they were least effective for those participants with high levels of conscientiousness. The research suggests that for some individuals the difference between intention and behaviour can be explained by differences in the personality traits of individuals. The problem of the transition between intentions and behaviours still does not seem to have been explained. However, the model of implementation intentions, while not suggesting a complete solution as to what exists in the gap, does present a solution as to how one might increase the likelihood of an individual reaching a desired goal through the development of mental constructs that define a desired goal-directed behaviour, in addition to being highly specific with regards to how it can be performed (when and where). As a result the behaviour is explicitly linked to a specific context and the means to accomplish the behaviour is defined using what is known about the context the behaviour will be performed in and possibly with consideration of hindrances to performing the specified behaviour. From the review of the literature so far, the greatest effects were observed in interventions based on implementation intentions. As a result, this thesis will describe the use of interventions based on implementation intentions to produce effective behaviour change in educational (as opposed to health) settings. The next section will describe implementation intentions in more detail.

2.4 What are implementation intentions and why may they be useful?

Research into attitudes and behaviour has explored how the attitudes of individuals and groups influence their behaviours (see Section 2.1.1). It has been noted that, although attitudes are very good predictors of intended behaviour, unfortunately they are not as accurate in predicting actual behaviour (Ajzen et al. 2007). In many studies individuals' intentions indicated they wanted to initiate a change of behaviour to a new behaviour i.e. quitting smoking or increasing the amount of exercise undertaken in a week. However, what was also found was that while intentions were good indicators of what an individual would aim to do, they were often found not to translate into observable behaviours. The TTM and the TPB do not describe the transition from an intention to a behaviour. However, the TPB incorporated an aspect called Perceived Behavioural Control (PBC). PBC suggests how confident an individual is in their ability to perform the behaviour. This construct appeared to be similar to that of implementation intentions in the sense that it aimed to help explain why intentions are not always the same as observable behaviours. Implementation intentions required the individual to form plans on how they could perform a behaviour, in doing so increasing their sense of PBC. The analysis suggests that motivation to perform desirable behaviours can be increased if the individual feels that the behaviour is both beneficial and achievable. By creating implementation intentions, it would seem that an individual’s motivation to perform a behaviour can be increased by highlighting that the desired behaviour can be performed. This section aims to describe how models of behaviour change based on *implementation intentions* (Gollwitzer 1999) may be used to help bridge the gap between intended behaviour, which seems to be accurately predicted, and actual behaviour which is less so (Webb and Sheeran 2007).

2.4.1 What is lacking?

It follows that if intended behaviour and actual behaviour are not congruent, then a change in one does not necessarily lead to a change in the other (in the case of changing behaviour through attitudinal change). Webb and Sheeran (2006) provide evidence that medium to large changes in individuals’ intended behaviour resulted in only small to medium changes in actual behaviour. What then seems lacking in some models where attitude is considered the most influential factor of actual behaviour is the distinction between actual and intended behaviours and more importantly how can the two be linked together or bridged such that changes in the intended behaviour are more likely to be reflected in the actual behaviour. A meta-analysis by Webb and Sheeran (2006) on behaviour change suggests that there is a considerable amount of research looking at changing intentions and behaviours with the use of implementation intentions e.g. Condom use (Caron, Godin, Otis and Lambert 2004). Such data suggest that the formation of implementation intentions does change health behaviours. However, a review of the literature (e.g. Webb and Sheeran 2006) suggests that a significant number of studies may lack adequate measures of individual intentions and behaviours or do not include a control group in the experimental design.

The majority of studies looking at behaviour change focus on health-related interventions. Currently there is little research related to attitudes of non-mathematics specialist students in higher education and none exploring the intention and behaviour gap in the domain of mathematics education and support. The research described in the literature exploring behaviour change and Implementations has focused predominantly on behaviours where there is a definable ideal usage that is seen as the target behaviour. Examples of this include the attendance at classes, job seeking and health-related behaviours where the optimal behaviour is to attend all of the classes and with job seeking, the greater the time spent on this behaviour the greater the possible chance of finding a job. In the case of health behaviours, this would be translated into using a condom 100% of the time, reducing the intake of fats as much as possible, exercising every day or stopping smoking. However, the use of Mathematics Support Centres by students is not a behaviour where more usage is necessarily better. Students who do not have many areas which need to be developed could either intend to use the services infrequently (the student does not require very much support) or frequently (very conscientious and wants to make use of all opportunities available). Students who have more areas that need development could need to use the services more often. It should be noted that the above is further complicated by considering the differences in type of support required by the student: a weaker student may need a small amount of support with many areas of mathematics. Whilst a stronger student may need more support with a single area of more advanced mathematics.

2.4.2 Mediators and Moderators

Although there is some evidence to suggest that forming implementation intentions leads to an increased likelihood of individuals being able to make the transition from intentions to behaviours, how is it that these self-constructed statements are able to bring about such changes in the observed behaviours of individuals? Also are these effects universal and generally applicable to all individuals? In the previous section it was suggested that there are factors that may possibly impinge on the effectiveness of implementation intentions (van Hooft et al. 2005, Webb and Sheeran 2007).

Von Hooft described the factors as mediators as constructs which bridge the gap between an intention and behaviour. The mediator that will be explored in this research will be the type commonly referred to as an implementation intention (Sheeran et al. 2005, van Hooft et al. 2005, Webb et al. 2007, Webb and Sheeran 2006). The mediators act as planning steps and in a sense are tangible rather than abstract goals. Similarly, the effectiveness of a mediator in the facilitation of the behaviour may be affected or governed by other factors called moderators such as personality (Webb and Sheeran 2007) that may either inhibit or increase the effectiveness of the constructed implementation intentions.

2.4.3 Structure of an implementation intention

Research into the use of implementation intentions and the mechanisms by which they may work has suggested that the statement acts in a priming fashion to allow the individual to more easily identify situations involving the “If X” part of the implementation intentions, i.e. individuals are more able to see the X’s or cues than those who have not formed implementation intentions. These situations become significantly more accessible to the individual compared to that of other situations (Sheeran 2002).

Gollwitzer (1996) suggests that at any point in time where an individual has a choice of action there may be numerous possible alternative actions which could be performed. Each possible action then needs evaluation (what is the result of performing that action and how easy the action is to perform), this being reminiscent of the evaluative function of attitudes as described by the theory of planned behaviour (Fishbein and Ajzen 1975, Ajzen 1985). This suggests that for each overarching goal there may be a number of possible behaviours which may or may not have been evaluated (i.e. the formation of an attitude about an attitude object). Each of these possible actions can be considered as being a coping strategy for the overarching goal intention or proposed behaviour. As pointed out by Webb and

Sheeran (2007), the possible time and cognitive effort required to evaluate the alternative behaviours may result in a missed opportunity for some potentially beneficial behaviours.

Recent work by Webb and Sheeran (2007) supports the idea that once the implementation intention has formed, the need for re-evaluation of attitude objects or even evaluation or sorting of alternate possible actions is not needed. The action is then less dependent on thought and relies more on the stimulus-action link (provided via the implementation intention), thus suggesting that the action could also be somewhat less influenced by attitudes and summary evaluations. Not all possible actions related to a goal intention or behaviour intention may result in the achievement of the desired goal. It is suggested that in addition to implementation intentions or plans that can be considered beneficial (i.e. facilitate the achievement of the goal intention or behaviour intention), there are other plans which may exist that have the effect of working to the detriment of achieving the goal intention (Achtziger et al. 2008). Actzinger et al. (2008) suggest that detrimental thoughts and actions can hinder the achievement of goal intentions, however it was also suggested that the use of implementation intentions can be used to reduce the effects of unwanted or detrimental behaviours i.e. goal shielding.

2.4.4 How do implementation intentions fit with other theories?

Models of behaviour change based around implementation intentions do not seem to contradict other models but rather supplement other prevalent models such as the Theory of Planned Behaviour (Ajzen 1985) and models that talk about habits e.g. The Theory of Interpersonal Behaviour (Triandis 1977) and Prototype/Willingness (Gibbons, Gerrard and Lane 2003). In the Theory of Planned Behaviour (see Section 2.1.2) attitude is described as having 3 components each of which has 2 sub-components. It has been suggested that the most influential of the 3 components is the one consisting of control beliefs and perceived behavioural control (Armitage and Conner 2001). According to the theory of planned behaviour, the level of perceived behavioural control is highly influential to the congruency between intention and behaviour. Control beliefs describe facilitators or hindrances that can affect the performance or carrying out of the behaviour, possibly a mixture of internal factors such as perceived skill and external factors such as knowing that the behaviour can be performed better in the presence of A or B. Perceived Behavioural Control is the individuals evaluation of the control beliefs such that the resulting evaluation is a measure of how easy or difficult the performance of the behaviour is.

However, the perceived behavioural control is not necessarily the same as the reality of how easy the ability is to perform and is subject to other factors including environmental factors. The likelihood of adopting the behaviour and ensuring that the behaviour is congruent with the intention is significantly increased if the level of perceived behavioural control is high and closely matches/approximates the actual/real level of behavioural control or actual behavioural control (Ajzen 1991) e.g. the individual perceives their skill at juggling to be high and their actual ability when observed agrees with this, or perhaps the equipment required to perform the behaviour is absent.

In Section 2.1.4 it was suggested that the construction of implementation intentions heightened cue detection in addition to triggering an observable response in the form of actual behaviour. In terms of the TPB it is plausible to suggest that there is some similarity between PBC and the implementation intention in the sense that the PBC is an indication of how easy or difficult it would be to perform a particular behaviour. The Implementation intention may serve two purposes in that, firstly, it is a statement which defines an achievable action and when it should be or can be performed. This plan is in essence stating the when, where and how of an achievable behaviour; it could then be reinforcing or increasing the level of PBC. Secondly, it is increasing the individual's ability to identify the situation described in the "If X then Y" statement, i.e. not missing out on opportunities to perform the behaviour. In constructing the plans, individuals need to think about such variables as the environment and their self-efficacy in order to create a sensible implementation intention. Due to the identification of possible conditions under which the behaviour could be performed it is possibly more likely that an individual will construct an implementation intention (and thus increase PBC) such that their PBC is closer to the actual behavioural control by constructing scenarios that are more likely to occur and furthermore when these scenarios do occur they are more likely to be picked up (heightened cue response).

Research (Adriaanse, Gollwitzer, De Ridder, De Wit and Kroese 2011; Danner, Aarts, Papies and Vries 2010) also suggests that the cue-response link formed through implementation intentions appears to interact with past behaviours and also the effect of habits on future behaviours. Where implementation intentions (strong cue-response links) are formed they have the effect of reducing the effects of habits. However, the research suggests that the implementation intention provides another strategy or response to a given cue. Only in cases where the cue-response is strong does the implementation intention have the effect of reducing the effect of the previous habits (Parks-Stamm, Gollwitzer and Oettingen 2007).

2.5 SUMMARY

This chapter has discussed the mental constructs of attitude objects and attitudes and how these are key components in many models of behaviour change that are currently used extensively in changing health behaviours (i.e. The Theory of Planned Behaviour and The Trans Theoretical Model of behaviour change). Though the models suggest a process of change based on attitudes and leading to actual behaviours, the method by which an individual makes the transition from intended behaviour to an actual behaviour was omitted in many models of behaviour change. Implementation intentions are suggested to help bridge the gap between intentions and behaviour. Through the construction of these “If X then Y” plans, individuals would be better able to identify situations and associated actions than if they had no constructed plans. Forming implementation intentions can also lead to quicker and more instinctive responses by having the decision to act not based on some evaluative function but rather as a response to a cue. However, positive evaluations of possible behaviours and actual control (i.e. high levels of motivation) are still required for implementation intentions to work effectively. A review of the literature found that the types of behaviour that tend to be looked at in the literature are those where either abstinence (of negative or detrimental behaviours) or gorging (beneficial behaviours) are encouraged. What is of interest is how this kind of intervention can be applied to contexts where the ideal level of behaviour is different for each individual as in the case of Mathematics Support Centre usage.

Chapter 3 Education, personality and behaviour change

In the previous chapter, the role of attitudes, external/internal motivations and habits were argued to be influential in explaining an individual's behaviour. The gap between the intended behaviour and actual behaviour was also highlighted and found to be substantially different from behaviour. Past literature suggested that the formation of implementation intentions could help address the difference between intention and behaviour. While attitudes and models of behaviour change have suggested how and why individuals behave in particular ways, personality has also been used to explain some types of behaviour. Of particular interest is how personality might be used to explain some of the variance in the academic achievement of students. Chapter 3 therefore reviews the demonstrated relationships between personality and achievement and then discusses how this could relate to study behaviours, attitudes and the use of implementation intentions as a means to promote mathematical study behaviours.

3.1 Personality and achievement

As indicated in Section 1.1.2, there have been concerns over the mathematical attainment of students who have been entering Universities across England. It has been suggested that there may be some relationship between personality traits and academic achievement (Komarraju et al. 2009, Allik and Realo 1997). The literature also suggests that there is some inconsistency in the relationship between personality and academic achievement. However, it should be noted here that intelligence is not the same as achievement. Although Deary, Strand, Smith and Fernandes' (2007) carried out a longitudinal study, which looked at the relationship between intelligence and attainment (GCSE grades) of over 70,000 children and found that students' intelligence scores when aged 11 and their GCSE achievement at the age of 16 were highly correlated (r = 0.81).

A study by Komarraju et al. (2009) looked at how personality could be related to both motivation and achievement (amongst 308 undergraduate students at an American university). Of particular note is their finding that conscientiousness, openness, neuroticism and agreeableness as measured using the 60 item NEO Five Factor Inventory (NEO-FFI) as constructed by Costa and McCrae (1992) accounted for 14% of the variance of Grade Point Average (GPA) scores whilst only 5% could be accounted for by intrinsic motivation. This suggests that personality may have a greater influence on attainment than the degree of personal motivation. It is worth mentioning here that high levels of conscientiousness could be considered to contribute to an individuals personal motivation. Komarraju et al. (2009)'s research also showed that amongst their sample, there was a significant positive correlation between GPA scores and scores on the conscientious (r = 0.29, p < 0.01), agreeableness (r = 0.22, p < 0.01) and openness (r = 0.13, p < 0.05) scales. A similar study by Allik and Realo (1997) looked at the correlation between measures of intelligence (intelligence test, historical knowledge, writing ability, foreign language) and personality (neuroticism, extraversion, openness to experience, conscientiousness and agreeableness as measured using the NEO Personality Inventory Revised as constructed using by Costa and McCrae 1992) among students (*N* = 381) during the application process to a university. This study found weak but statistically significant correlations between the personality scales and general ability as measured by the intelligence test. In particular, the intelligence test scores were found to be negatively correlated with conscientiousness (r = -0.19, p < 0.001) and agreeableness (r = -0.18, p < 0.001). Extraversion was not found to be correlated with any of the measures of intelligence.

Similar to the study by Allik and Realo (1997), the effect sizes reported by Komarraju et al. (2009) suggest that individual conscientiousness has the greatest correlation with GPA scores. While Komarraju et al. (2009) found a positive correlation between conscientiousness and achievement (measured using GPA scores), Allik and Realo (1997) found a negative correlation between conscientiousness and intelligence which is not in line with Costa and McCrae (1992, 2002) who suggest that there is a positive correlation between intelligence scores and conscientiousness. Though performance on GPA and intelligence are different tests, it would seem sensible to suggest that those with a higher intelligence would likely achieve higher on GPA. The above two studies suggest correlations between achievement and conscientiousness that are contradictory (one was a positive correlation while the other was negative).

A longitudinal study by Honzik and MacFarlane (1973) was carried out with 60 males and 60 females. The study looked at intelligence and personality of participants at the ages of 18 and 40. Their study found a negative correlation between intelligence and agreeableness (in line with more recent research by Allik and Realo 1997). The studies described above suggest that personality could be related to academic achievement. More recent research by Komarraju (2009) and Costa and McCrae (1992, 2002) suggests a positive correlation between conscientiousness and intelligence. This suggests that the direction of this relationship is unclear. The small to medium effect sizes combined with the inconsistency in the direction of the relationships suggest caution in any conclusions that are drawn about the relationships between the measures of intelligence and achievement with personality.

The influence of conscientiousness on attainment is highlighted by the use of the Hogan Personality Inventory (HPI) by Martin et al (2006) who conducted a four-year longitudinal study which looked at the effectiveness of personality measures and pre-entry academic assessments as predictors of undergraduate performance in the form of GPA scores for undergraduates (N = 587) at an American university. Their study showed that there was a correlation between GPA and both Prudence (positive correlation) and Sociability (negative correlation), where Prudence was used as a measure of conscientiousness and Sociability when combined with ambition was considered a measure of extraversion (NEO and EPQ). However, it was also shown that over the four years the strength of the correlations decreased, which suggests that tuition might attenuate the extent of any relationships between personality and attainment. Fruyt and Mervielde (1998) also found conscientiousness as measured by the NEO-PI-R (Dutch Flemish version) to be a predictor of the achievement of 934 final year undergraduate students of various disciplines from Belgium. Their results suggest that conscientiousness correlated with achievement on the first set of exams in the final year ($r = 0.35$, $p < 0.001$) and the final grades ($r = 0.28$, $p < 0.001$). This result is partially consistent with the results of Martin et al. (2006) in the direction of the correlation. However, it is not possible to ascertain whether the correlation was stronger in previous years.

The interaction between behaviour and personality is an important one to consider in the context of implementation intention research and educational performance, because the effectiveness of implementation intentions as an intervention strategy may be moderated by individual differences in the students' personalities. For example, the effectiveness of implementation intentions in an educational context could be negatively correlated with the trait of psychoticism (or positively correlated with the trait of conscientiousness, see Lodhi, Deo and Belhekar 2002). Lodhi, Deo and Belhekar (2002) suggest that there is a negative correlation between conscientiousness as measured using the *Neuroticism, Extravertion & Openness Personality Inventory-Revised* (NEO-PI-R) and psychoticism as measured using the

Eysenck Personality Questionnaire-Revised (EPQ-R) (r = -0.33, p < 0.001). The relationship between conscientiousness and psychoticism suggests that that low scorers on the EPQ-R psychoticism scale (high scorers on the NEO conscientiousness scale) will tend to be more meticulous, organised, better at planning and also more able to self-motivate themselves towards a goal; as a result it is plausible to argue that both measures relate directly to an individual's personal study behaviours, beliefs and possibly academic achievement. However, it should be noted that the psychoticism and conscientiousness scales measure different aspects of personality and it would be unwise to infer that the two scales are measures of the same construct. Positive correlations between conscientiousness and academic attainment have been found by Martin et al. (2006) and de Fruyt and Mervielde (1998). However, the correlations have tended to be weak and suggest that personality may not fully explain the variance observed in achievement.

The evidence presented so far suggests that there is an inconsistent relationship between extraversion and academic achievement, although the aspect of personality measured variously as 'conscientiousness' and 'psychoticism' does appear to have a more consistent relationship with academic achievement. However, it is important to note that not all studies use the same scales for measuring personality; for example the *psychoticism* scale on the EPQ instrument can be thought of as an amalgamation of *conscientiousness* and *agreeableness* scales on the NEO instrument. A meta-analysis by Wolf and Ackerman (2005) suggests that past research has identified statistically significant correlations between intelligence (including numerical ability) and the extraversion personality trait. Wolf and Ackerman also suggest that the magnitude of the positive correlation has decreased over time and that more recent studies imply a negative correlation. The extraversion trait also suggests that extraverts' and introverts' behaviours when taking tests were different (Eysenck 1994); introverts being slower but being more accurate compared to extroverts who were quicker and made more errors. This suggests that students who are more extroverted are likely to score lower on tests designed to measure mathematical ability compared to those who are introverted. However, this does not suggest that extroverts are less able or intelligent than introverts, it does suggest that they are more prone to errors and mistakes due to excessive haste. These data also suggest that measures of extraversion alone may not be used to predict intelligence, mathematical ability or achievement reliably.

The levels of extraversion may have an influence on the individual's ability or willingness to work as part of a group. Many learning theories suggest that the process of learning is most effective when individuals are able to work with each other. Barry and Stewart (1997) found that extroverts were often perceived as contributing more to the outcomes of a group activity. The literature does not suggest whether these observations are correct across all areas of learning or whether they are localized to specific areas e.g. literacy, mathematics or art. It is also unclear from the literature if there are differences between student groups in their personality or mathematical ability (on courses that do not require more than a GCSE in mathematics at entry). Personality differences that influence students' preference for working in groups along with the roles within the group situation may also then have an impact on the effectiveness of collaborative learning (e.g. Vygotsky 1978, Lave and Wenger 1991, Wenger 1998).

3.2 Educational Behaviours

One of the similarities between the theories discussed in the previous chapter (Section 2.2.4) was the salience of motivation. This construct was observable in the both the Theory of Planned Behaviour (TPB) and the Transtheoretical Model of Behaviour Change (TTM) described in the previous chapter. Within education, students' motivation has been considered a predictor of how well students will engage with the learning process (e.g. Komarraju and Karau 2008, Linnenbrink and Pintrich 2002). Motivation is also a dominant model of behaviour change in educational research (Section 2.2.4). Much of the current literature has focused on how motivation towards learning can be increased so that there is increased engagement with learning processes (Artino and Stephens 2009, Schiefele and Csikszentmihalyi 2005). Motivations have been categorised as belonging to two groups that define the origin of a so-called reward for the performance of a particular behaviour or task (Lepper 1988, Ryan and Deci 2000b). Intrinsic motivations originate from oneself (e.g. enjoyment of the proposed activity or a personal challenge). Extrinsic motivations are categorised as external rewards, such as punishment avoidance, increased salary, better job, social acceptance or peer praise. The research literature suggests that strong intrinsic motivation for performing learning behaviours is more likely to enable an individual to initiate and maintain these behaviours (Mehta, Clayton and Sankar 2007; Weinert and Kluwe 1987; Lucas 1990).

It is also noted that intrinsic motivation is something that is harder to influence than extrinsic motivation and some have argued that it is essentially bad to try to use extrinsic motivation to change behavior as it erodes the intrinsic motivation of an individual through the perceived reduction in control or ability to perform the behavior without external pressures (Deci, Koestner and Ryan 1999). It is for this reason that within the context of this thesis motivation was not looked at. Furthermore, a method of behaviour change that did not rely on external rewards or motivations was sought; motivation and the models of behaviour change that have been described can only explain the intention to perform a particular behaviour. It is possible that student's could create implementation intentions out of a wish to perform better in examinations. However, the implementation intention itself does not need to refer to any extrinsic motivator.

One of the important study behaviours that was described in Chapter 1 was students' use of the Mathematics Support Centre. Those who were found to be motivated to use this service seemed to be improving their mathematical ability (Section 1.1). Mathematics Support Centres such as those at Coventry University offer learning spaces where students can work collaboratively with their peers if they choose. The space where drop-in support is offered is the same as where students may engage with group work. Social Constructivism (Vygotsky 1978) suggests that learning is more productive when performed as a collaborative process; i.e. when individuals work with others rather than in isolation. Vygotsky suggested that learning is a collaborative process where knowledge is constructed through interactions between learners (peers) and those of greater skill (more able peers or instructors). The notion of collaborative learning has also been highlighted by Lave and Wenger's work on communities of practice (Lave and Wenger 1991, Wenger 1998). However, it is important to note that collaboration and learning as a group idea is dependent on the individuals and how they interact with each other. Eysenck and Eysenck (1991) suggest that personality traits such as extroversion and psychoticism can influence how individuals interact with their peers: introverts being more likely to prefer working alone whilst extroverts are more likely to engage with group based activities. Similarly, those scoring higher on psychoticism measures may be more inclined to work alone rather than collaborate with peers. The literature suggests that introverts do not have an aversion to small group work though they may approach working in groups differently from those characterized as extroverts. Research suggests that when working in small groups extroverts are more likely to work together through discussion and the use of counterexamples and contradictions whereas introverts are more likely to work together collaboratively to form creative solutions (Nussbaum 2002). This reflects the findings of Barry and Stewart (1997) who found that within a group, extroverts were perceived to contribute more than those who were more introverted, possibly due to their use of contradictions and counterarguments. As many Mathematics Support Centres also facilitate collaborative learning in addition to providing one to one support, it is possible that a student's level of extroversion and psychoticism could indirectly influence how much time a student spends using the Mathematics Support Services.

What is not clear from the literature is if this is true in all areas of learning or just isolated to certain areas e.g. numeracy, literacy or foreign languages. Furthermore, it is unclear whether there are significant differences in the personality and mathematical competencies of students from different courses. In particular, differences in personality may influence how individuals prefer to study for example individually or within groups (e.g. Vygotsky 1978, Lave and Wenger 1991, Wenger, 1998). If the students have high levels of extraversion and low levels of psychoticism it is possible that these students would be more likely to make use of the group study areas where there is more opportunity for contributing to discussion in addition to receiving support. What has not been found in the literature is any empirical analysis of the relationship between usage of Mathematics Support Centres and personality measures.

3.3 Personality measurement

Section 3.1 suggested that personality measures could not accurately be used to predict academic achievement but may be a factor in the effectiveness of implementation intentions as a method of behaviour change in educational contexts (Section 3.2). Personality can be measured using a number of different instruments that measure a number of facets of personality. These instruments differ in the number of question items, number of traits being measured and also the type of response required from participants. A short description of three commonly used instruments is given below:

- NEO PI-R (**Revised NEO Personality Inventory) –** 240 items measuring neuroticism, extraversion, openness, agreeableness and conscientiousness (Costa and McCrae 1985).
- EPQ – R (**Eysenck Personality Questionnaire revised version**) – 106 items measuring neuroticism, extraversion and psychoticism (Eysenck and Eysenck 1975).
- MMPI-2 (**Minnesota Multiphasic Personality Inventory**) – 567 items long form and 370 items short form measuring Hypochondriasis, Depression, Hysteria, Psychopathy, Masculinity/Femininity, Paranoia, Psychasthenia, Schizophrenia, Hypomania and Social Introversion. The original MMPI was developed in the 1930s and 40s by Hathaway and McKinley (1940).

There are many other personality inventories similar to the three described above. Each inventory is composed of numerous facets or possible subscales that, through factor analysis, have been reduced down to a smaller number of traits which the inventories aim to measure and quantify. However, it should be noted that as the number of subscales/facets that are measured increases the number of items in the inventory increases. Many of the inventories contain additional scales that aim to add validity to the results by measuring the degree to which a respondent would be inclined to lie or respond in a manner which is not reflective of their true personality, in effect a measure of the distortion of actual personality. The majority of instruments aim to measure either all or at least a subset of the 'big five' personality traits (also known as the 'five factor model'): neuroticism, extraversion, openness, agreeableness and conscientiousness (e.g. NEO PI-R). The choice of instrument used for any particular study should be informed by the nature of the study. Major issues would relate to the length of the personality inventory and facets of personality that are of interest. The literature in Section 3.1 and 3.2 suggests that personality measures could to a small extent predict achievement (however, the measures would only be able to explain a small amount of the observed variance). Measures of extraversion could be useful in explaining the collaborative learning preferences of individuals and in turn why some students make more use of a Mathematics Support Centre.

3.4 STABILITY OF PERSONALITY

In the previous sections the possible importance of personality in educational research was discussed, and in Chapter 2 a model of behaviour change involving implementation intentions was introduced. Interventions of this kind are best tested through a pre-post design with control and treatment conditions. To test the effectiveness of the implementation intentions on improving the usage of Mathematics Support Centres whilst taking into account the effect of personality it seems sensible to ascertain the contextual and temporal stability of these constructs. If personality is stable then it can be assumed that personality measures taken at either pre-intervention or post intervention are representative of a participant's personality between measurements. If there are significant instabilities in personality variables over time then it is not possible to be certain of the level of a personality measure at times other than when the variable was last measured.

3.4.1 *Temporal stability of personality*

A study by Conley (1985) found that self-report measures of major personality traits were stable during adulthood. However, in the case of adolescents, the stability of personality has been found to vary across individuals (Roberts et al. 2001). Roberts' longitudinal study looked at personality traits (10 scale MPQ personality test) amongst young adults aged between 18 to 26 years of age. It was found that for the majority of individuals there was a significant change on 1 or 2 of the scales.

Monika (2000) suggests that much of the research which claims stability of the personality construct has only been conducted over short time periods. Moreover a longitudinal study taking place over 40 years (Hampson and Goldberg 2006) suggests that the stability is far greater for adults than it is for children (over a 3 year time period). Hampson and Goldberg also found evidence to corroborate earlier studies

(Haan et al. 1986, Soldz and Vaillant 1999) which suggested that there was a low correlation between the measured personality of individuals at childhood and then at adulthood. In the above studies, individual traits such as extraversion and Neuroticism have been shown to vary in the degree to which they are unstable over time. For example extraversion was found to be stable (Hampson and Goldberg 2006, Von Dras and Siegler 1997) to the extent that Von Dras and Siegler suggest that the extraversion of adolescents was predictive of their level of extraversion in midlife. Whereas the research on neuroticism suggests that there is more variability. Some would suggest that there is a high level of stability (Birley et al. 2006, Veronique De 2003), whilst others suggest there is little to no stability of this trait over time (Hampson and Goldberg 2006). From the research described above, it would seem sensible to draw the conclusion that fluctuations in personality traits are more observable when the separation between measurement is medium to large (approximately in excess of 3 to 4 years), while on a smaller scale (i.e. less than 3 years) there is less variability or change. However, certain traits 'may' be more resistant to change than others. As a result it would seem that as the time between measurements increases, the level of caution should correspondingly increase when assumptions are made about the personality of an individual between the two measurements or when predicting the attitude at some arbitrary time after the initial measurement. Based on the above it is suggested that there is little variability in personality traits when the time between observations is less than 3 years and as such it is assumed that over periods of time less than one year apart, personality can be assumed to be stable with variation not being statistically significant.

3.4.2 Contextual stability

Monika (2000) suggests that studies which have shown that personality is stable over time may not have taken the contextual or situational influences into account when drawing conclusions about temporal stability. It was mentioned in Section 2.1.1 that attitudes towards attitude objects could be context dependent or situated. It would seem that current research (Mischel 1984, Shoda and Mischel 2000) would similarly suggest the contextual dependence of personality and the implications this may have on the cross-contextual validity of personality measurements. Research by Heller et al. (2007) for example, would suggest that although an individual's overall personality may be relatively consistent across contexts; trait-wise examination of personality reveals that there is an observable variability in personality due to changes in the context (more specifically the change in the behavioural role of the individual which is brought about by a change in the context). The examples given by Heller refer to roles in society such as mother, student, manager, employee, friend etc.

3.4.3 Overall stability of personality constructs

It has been suggested in this chapter that according to research, personality when measured using personality scales is a construct that may be subject to both temporal and contextual instability. However, looking at the context of educational behaviours of students in a university context it seems valid to make the following assumptions:

1) Due to the short time span (3 to 4 years) between the start and end of a course of study personality traits could be assumed to be stable and relatively unchanging.
2) Contextual dependence would not be an issue as long as the context and role of the student was unchanged. In the case of undergraduate students the context and role could be assumed to be invariant i.e. student in a university learning environment.

3.5 RATIONALE FOR THIS THESIS

This section aims to summarise the findings from the literature discussed in Chapters 1 to 3. Furthermore, this section will propose an intervention (based on implementation intentions) aimed at improving the usage of Mathematics Support Centres. An identified problem with the mathematical abilities of students is that there is a mismatch between ability and course demands in many cases (Hawkes and Savage 2000). This has been a problem for a number of decades, and appears to be getting worse (Kounine et al. 2008, Williamson, Hirst, Bishop and Croft 2003). A number of strategies have been put in place by UK universities to address this problem (see Section 1.2.2) and to try and help students to improve their mathematics and reduce the mismatch between the requirements of the courses and the abilities of the students. One of the popular solutions mentioned was the provision of Mathematics Support Centre type services (see Section 1.2.3) which allow students to obtain support with any mathematics or statistics type problem. However, not all students choose to make use of the strategies on offer. In particular usage data from Coventry University suggested that students from Health and Life Science courses accounted for less than 1% of the users of the Mathematics Support Centre. It was highlighted that only those who engage with the services on offer could expect to realise any potential benefits (see Section 1.2.4). Furthermore, the low usage identified amongst weaker students in particular would suggest the need to better engage students with the support services on offer to help reduce the effects of the problems highlighted in Chapter 1.

Attitudes have for a long time been seen as a mental construct that can predict an individual's behaviour (Sections 2.1.1 and 2.2.1.1). However, a review of the models (Sections 2.1 and 2.2) of behaviour change and the empirical evidence suggests that attitudes are good predictors of an individual's intention to perform a behaviour but not a good predictor of actual behaviours. With respect to the usage of Mathematics Support Centres, it seems that an individual who feels the need to improve their mathematics abilities may well try to improve their skills by intending to use various support services however this intention may not always realised. Sections 2.3 and 2.4 highlight how the gap between intentions and behaviour could be bridged using implementation intentions. The use of implementation intentions in the literature has focused on mostly health-related behaviours and more notably where the most desirable outcome is either complete cessation or complete adherence to a particular goal-directed behaviour. It was noted that intrinsic motivation is something that is harder to influence than extrinsic motivation and some have argued that it is essentially bad to try to use extrinsic motivation to change behaviour as it erodes the intrinsic motivation of an individual. It is for this reason that, within the context of this thesis, motivation was not addressed directly. Furthermore, a method of behaviour change that did not rely on external rewards or motivations was sought. Educational research has focused mainly on motivation, attitudes and self-concept as a means to explaining behaviour (see Section 2.2.1.1). It is acknowledged that motivation and attitudes are important in the study of educational behaviours. However, Norwich (2000) suggests that the knowledge base and techniques used by those involved in educational research varies depending on the environment and department in which the researchers work. As those involved in educational research may not have a familiarity or working knowledge of the same theories as Academic Psychologists. Furthermore, a report from Ofsted (1999) highlighted the problem of poor research in education including methodological and non-empirical research based weaknesses. The Ofsted report found that the main issues related to subjectivity in the interpretation of data in qualitative case studies (e.g. through misogyny, sexism or racism) and sampling information. A general lack of detail in the reporting of studies was found which was suggested to not reflect good practice in educational research e.g. the sample size, how participants were selected, what populations were sampled etc. Of the journal papers reviewed by Ofsted, approximately 50% to 70% of the papers reviewed lacked sufficient detail for the studies to be replicated. The majority of the papers reviewed were found to be qualitative or theoretical in nature.

Research is lacking regarding behaviours where complete adherence or cessation are not required as target or ideal behaviour in an educational context. An example of this kind of behaviour is with mathematical study where a weak student may require minor assistance with an elementary numeracy issue or where a strong student desires regular and lengthy support on a more advanced problem.

Finally, Sections 3.1 to 3.4 highlighted how personality could be a moderating factor between intention and behaviour. The literature suggests that this construct could be a predictor of both achievement and effectiveness of implementation intentions. However the use of personality as a predictor of effectiveness of implementation intentions has been limited to situations where complete adherence or cessation is ideal. Attitudinal research (including personality) up until now in the area of mathematics has been limited to students who have had a continuous history of studying mathematics, for example engineering students (Shaw and Shaw, 1997). This is significantly different from the students who are at the focus of the research presented in this thesis. Students who will be involved in this research do not have a continuous history of mathematics and in many cases have made a decision prior to entering university that they did not want to study mathematics further after their compulsory schooling was complete.

The research described in this thesis aimed to address the gaps in the literature as outlined above by exploring how implementation intentions can be used to increase the use of mathematics support services by undergraduate students. Furthermore, rather than focusing on the mathematical abilities of mathematics undergraduates, this research aimed to explore the effects of an implementation intention-based intervention on students whose chosen courses of study did not require an understanding of mathematics higher than GCSE prior to entry (e.g. psychology).

Following on from the summary above, this thesis aimed to explore and discuss a strategy for improving the engagement of students with Mathematics Support Centres using interventions based on implementation intentions. The thesis also examined the differences in personality between groups of students and the correlations between personality and mathematics ability to inform discussions of how best to facilitate students' learning of mathematics related content e.g. within quantitative research methods and statistics.

This project primarily aimed to answer two questions related to the effectiveness of implementation intentions applied to a mathematics education context. Firstly, do implementation intentions increase students' usage of Mathematics Support Centre? Secondly, does personality or mathematical ability influence the effectiveness of the implementation intentions?

In addition to the two primary research questions described above, the project aimed to answer two secondary research questions. Firstly, are there differences in personality and mathematical ability between students from different courses? Secondly, is there a relationship between personality and mathematical ability?

CHAPTER 4 - METHODOLOGY

In the previous chapters, a discussion of the apparent decline in the mathematical abilities of undergraduate students was highlighted. Mathematics Support Centre services such as those provided by Coventry University provide mathematical support to students across disciplines. In Chapters 2 and 3 it was argued that the use of such services could be improved through the use of interventions that aim to change students' study behaviours. Furthermore, in Chapter 3 it was suggested that personality could play an important role in influencing educational behaviours particularly those related to approaches to learning. The aim of this project is therefore to explore the effectiveness of applying an intervention based on implementation intentions (Gollwitzer 1996, 1999) to improve the use of mathematical support services, and to understand whether individual differences in personality influence such an approach.

Research Questions

Three studies were carried out to answer the following research questions:

- Do implementation intentions increase the usage of Mathematics Support Centres?
- Does personality or mathematical ability influence the effectiveness of the implementation intentions?

In addition to the two primary research questions described above, this project aimed to answer two secondary research questions:

- Are there differences in personality and mathematical ability between students from different courses?
- Is there a relationship between personality and mathematical ability?

To answer the research questions above, studies were designed to implement and evaluate an intervention approach based on implementation intentions. The intervention was designed such that individuals would form implementation intentions that promoted increases in the time spent engaged with mathematical study outside of formal lectures and workshops. The main focus was to ascertain if those who engaged with this type of intervention showed greater increases in the amount of time spent studying (including the use of Mathematics Support Centres) compared with those who had not been exposed to that intervention. Furthermore, it was decided to focus on non-mathematics students from Coventry University and the time they spent engaged with mathematical study before (both private study and the use of the Mathematics Support Centre of Coventry University) and after the intervention.

The aim of this chapter is to describe in detail the Pilot Study and two main studies. The Pilot Study was carried out to trial the instruments and recruitment strategies prior to using them in the two main intervention studies (Studies 2 and 3). A detailed account of the main intervention studies including an analysis and discussion of the results of each study will follow in Chapters 5, 6 and 7.

4.1 Outline of the studies

This section describes the three studies that were carried out as part of the overall project and briefly discusses the purposes of each study in relation to the research questions and the overall design of the project.

4.1.1 Pilot Study (Study 1)

The main study carried out during the 2008/ 2009 academic year gathered data on social desirability, study habits (time spent engaged with mathematical study), personality, mathematical ability and demographics. Prior to carrying out the main study, a pilot study was carried out in April 2008 to trial the first versions of the instruments developed for measuring mathematical ability, study habits and demographic data. Through the trialling of the instruments it was possible to inform the development of the instruments as used in future studies. As a consequence of the pilot it was also possible to explore which recruitment strategies would be best for maximising the number of participants.

4.1.2 The Academic Year Long Intervention Study (Study 2)

Improvements to the instruments were informed by the results of the Pilot study and implemented in a study that spanned one academic year (October 2008 to May 2009). This study aimed to test the effectiveness of implementation intentions using a pre-post experiment. Participants were allocated to either the control or treatment condition (implementation intention intervention). The participants in each condition were assessed on mathematical ability (pre and post), personality (pre), study behaviours (pre and post) and socially desirable responding (pre). Concurrent data pre-intervention were examined to explore relationships between personality and mathematics ability (secondary research question) and whether there were differences in personality and mathematical ability between students from different disciplines (secondary research question). The pre-post data were examined to explore the effectiveness of implementation intentions in improving mathematical study behaviours and also if personality influenced the effectiveness of the implementation intentions (primary research question).

4.1.3 The One Term Long Intervention Study (Study 3)

Data collected during Study 2 suffered from high levels of attrition and resulted in a smaller than expected sample size when examining the pre-post data. A further study was therefore carried out during September 2009 to December 2009 to gather additional data. The opportunity to collect additional data also provided the chance to refine the instruments further.

The One Term Long Intervention aimed to improve upon the previous study by using improved versions of the instruments and a refined treatment condition. Study 3 also aimed to collect data on study habits (pre and post) specific to the usage of the Mathematics Support Centre at Coventry University (whereas the previous study looked at study behaviours in a wider range of study locations, the implementation intentions created in the previous study were not solely focused on Mathematics Support Centre usage). Personality, mathematical ability, social desirability and demographic data were collected in addition to a measure of the quality of the implementation intentions that was formed by those in the treatment group. This study looked at the same research questions as the previous study. The remainder of this section examines the experimental design, instruments used within the studies in more detail and a detailed description of the pilot study.

4.2 GENERAL DESIGN CONSIDERATIONS

Designing an intervention study needs to take into account the research questions and sample size requirements. This section discusses the general design considerations used in the studies that were carried out, including careful attention to ethical issues.

4.2.1 DESIGNING INTERVENTIONS IN EDUCATIONAL RESEARCH

Research where the effectiveness of an intervention needs to be assessed generally uses experimental design (Field 2009: 12-15). The aim of these designs is to measure at pre and post test performance on an outcome variable once an independent variable has been manipulated (usually the application of an intervention compared to some form of control experience). An intervention in an educational context could be the use of a new teaching strategy (e.g. using a new piece of technology or virtual learning environments) in improving attainment or the effect of introducing a new assessment policy on the quality of student assessment.

It is not recommended that all participants receive the intervention; this strategy would mean that it would be impossible to determine whether any changes in the outcome variable were attributable to maturation effects alone (e.g. participants mathematical ability improving due to age and experience rather than through teaching). It is therefore essential to have participants randomly allocated to one of at least two groups; one group who were given the intervention and one who were not.

A concise description of a number of different types of intervention study designs is given in Fisher and Foreit (2002). They discuss true experimental designs such as the **pre-test post-test control group design** and **post-test control group design**. In both of the above designs participants are randomly assigned to either the control or the treatment conditions (of which there may be more than one of each). Randomisation is useful in that it can help to attenuate the effects of personal differences, group differences and maturation effects. The CONSORT 2010 statement (Schulz, Altman and Moher 2010) suggests that when designing randomised trials it is important to have individuals randomly allocated to one of two parallel conditions (e.g. treatment and control). The ratio of participant numbers in the groups should also be clearly reported. The statement also highlights the importance of properly and thoroughly describing both the control and treatment interventions.

The studies described in this thesis required participants to complete questionnaires and participate in the interventions within seminar and lecture theatres. Unfortunately, random allocation in these settings can result in contamination between various conditions (particularly in a lecture hall). For example, it may seem a good idea to randomly allocate students in a workshop if they were all participating in an experiment to find out if workshop notes containing illustrations were more effective at helping students grasp key mathematical concepts than text only notes. However, random allocation in this case could result in participants that had been allocated to different conditions sitting together. It is therefore possible that students sitting together are likely to discuss their tasks with those sitting adjacently. Random allocation also aims to control for individual differences and as such the random allocation can lead to the assumption that baseline measures are equal across groups (as with the posttest control group design). However, taking baseline measures prior to an intervention (as with the pretest posttest control group design) would help to ascertain the extent to which the randomisation had been successful in keeping the baseline measures the same across the conditions.

To reduce contamination effects within a lecture theatre, two options are available. The first option would be randomly assign the students a number corresponding to a condition. Participants would then move and sit with others in the same condition. However, this option immediately alerts the participants that they will not all be carrying out the same task. Furthermore, there is no guarantee that friends who have been split up through the random allocation will not discuss their individual tasks as they have already been alerted to the different conditions. A second option is the use of a quasi-experimental design where rather than each individual being randomly allocated to a condition, groups of participants could be allocated to each condition (not necessarily through random allocation). This strategy would not be as effective in reducing the effects of individual differences as there could be biases in the composition of individual groups of participants and as such the participants from different conditions may not be equivalent, however, the likelihood of contamination is decreased as there is less chance of participants from different conditions discussing the experiment with each other.

Intervention designs also benefit from being single blind or double blind to reduce biases (intentional or unintentional) during the collection and analysis of the data. Double blind experiments refer to those where both participants and the researcher are unaware of who has been allocated to which condition. Single blind experiments refer to those where only the participant is unaware of the condition they have been allocated to. As such, it would seem logical to aim to create double blind type experiments and if possible preserve the uncertainty in condition until all data has been analysed, though this may not be possible if data is entered and preliminary analysis is conducted part way through data collection.

The design of an intervention study needs to take into account the above considerations both in terms of the allocation of participants to conditions and to when and how the data is collected. These issues also have a direct impact on the creation and content of the intervention itself. The participants in the control and treatment conditions must not become aware of their allocated condition. To reduce the likelihood of participants becoming aware of which condition they have been allocated to, the control condition would need to appear similar to the treatment condition. These similarities could be in the theme of the treatment (i.e. maths related) and the time required for the two types of intervention. In order to assess treatment fidelity with respect to the intervention in this project it was necessary to evaluate and consider the intervention using the recommendations of Bellg, Borelli, Resnick, Hecht, Minicucci, Ory, Ogedegbe, Orwig, Ernst and Czajkowsji (2004). These suggest strategies for maintaining parity both within and between the control and treatment conditions. They recommend that the duration of contact with participants should be the same across and with conditions (length of intervention should be the same), that there are strategies in place to ensure that the treatment is administered consistently across all conditions and groups. They also suggest that strategies are in place to minimize the effects of contamination between groups. Further details of the intervention will be described in Section 4.4.5 of this chapter.

4.2.2 Sample size requirements

A power analysis was carried out in order to ascertain how many participants would need to be recruited such that data could be meaningfully analysed statistically, in addition to observing effects due to the implementation intentions. Assuming that details of the distribution of the population (and for each group) are unknown, estimates for the minimum sample size (and for each group), power and effect size are shown below using the methods described in Howell (1997: 213-226).

To estimate the minimum sample size that would be required for this study a power calculation was carried out. Cohen (1988) has suggested estimates for the effect size d for small (d = 0.2), medium (d = 0.5) and large (d = 0.8) effects. The power of an experiment is defined as the ability to correctly reject a hypothesis which is false. An experiment with a low power would be less likely to reject a false hypothesis (incorrect acceptance when false). However an experiment with a very high power is likely to have an increased risk of rejecting a true hypothesis (incorrect rejection when true). Powers (P) of at least 0.7 (0.8 is an arbitrary but commonly used figure) were required to confidently reject a false hypothesis; using a table of values (Howell 1997: 679) relating the quantities d and P (for a two-tailed experiment) it was possible to estimate d which would in turn allow an estimate of the required sample size to be calculated.

An estimate of the sample size for a given effect size and required power is displayed in Table 4.1. These estimates are based on the assumption of a between groups design. The N in each case is the number of participants within each subgroup. For a 2 group between groups t-test with a power of 0.8, to look for medium size effects would ideally require at least 126 participants in total.

Table 4.1: Calculation table showing the minimum sample size per subgroup required for different effect sizes per group in a 2 group experiment

Power* required (P)	Effect size**	d**	δ required	$N = 2\left(\frac{\delta}{d}\right)^2$
0.7	Small	0.20	2.48	308
	Medium	0.50	2.48	50
	Large	0.80	2.48	20
0.8	Small	0.20	2.80	392
	Medium	0.50	2.80	63
	Large	0.80	2.80	25
0.9	Small	0.20	3.25	529
	Medium	0.50	3.25	85
	Large	0.80	3.25	34

Where: *d* = effect size, *α* = 0.05 in a two tailed test, $\delta = d\sqrt{\frac{N}{2}}$, *Power refers to the effectiveness at rejecting a null hypothesis, ** Effect size refers to strength or magnitude of the relationship

The value of N in column 5 of Table 4.1 (above) suggests the minimum sample size required for a given power to effectively reject a false hypothesis. These numbers reflect an estimate of the minimum size for each group. If these are not met then it may not be possible to confidently reject or accept the hypotheses used to answer the research questions presented in Chapter 3. Prior to carrying out the studies described in this thesis, approximately 400 students were expected to participate in Study 2 (see Section 4.1.2), distributed between the different courses from which participants volunteered. Table 4.1 suggests that small effects may not be statistically observable for any reasonable level of power ($P > 0.7$). This is especially true if collected data was split according to subject group where some courses have less than 100 students in their 1st year intake.

However, from a practical viewpoint (i.e. financial and time) it would seem that large effects are more interesting, especially if the time and money spent administering the intervention only yielded a marginal or small improvement (this is not to say that a small or marginal improvement is inconsequential). For the purposes of this research, the finding of medium to large effects required a sample of at least 100 students per subject group (50 control and 50 treatment). However larger samples would allow for the observation of smaller effects with little reduction in power.

4.2.3 Recruitment strategies

Prior to the commencement of Studies 2 and 3, a number of strategies were trialled as part of the Pilot (Study 1) with the students at university (NB. details of the study are given shortly in Section 4.3). Students were informed about the research and the potential benefits (for themselves, their peers and further afield e.g. the research community and students elsewhere) of taking part in the research. The recruitment methods that were trialled in the Pilot study are described below.

Leaflets – Leaflets (A5 size) were created that briefly described the research and the potential benefits that may occur through participation in the study. Each leaflet also contained a link to a website which provided further information on the research project and how to participate (downloadable paper questionnaire or online questionnaire). It was important to ensure that the leaflets were placed in locations that were easily and equally accessible to all students. Also it was necessary to ensure that only students at Coventry University would participate in the research. For the above reasons leaflets were placed near the main entrance and exit of the library as well as at an outreach desk (run by the Mathematics Support Centre) which was also located within the library. Appendix 2.14 contains the design used for the leaflet.

Poster – A poster (A3) containing the same information as the leaflets was displayed in a newly built communal/group study area located in the basement of the library. As with the location of the leaflets it was decided to use these locations as they were deemed to have a high level of foot traffic when compared to other locations due to being located near the entrance and exits (see Appendix 2.14 for poster design).

Direct contact with students – Through discussions with the nursing department it was possible to have access to a cohort of 1st year nursing students (approximately 130). Access to the students was provided through a 10 minute briefing at the beginning of a timetabled nursing related lecture. During this time all it was possible to do was to distribute a small *research pack* which consisted of information and consent documents (see appendix 2.15), questionnaires (Appendices 2.2, 2.5, 2.8 and 2.11) and a leaflet (see above and Appendix 2.14)

The pack was distributed to all of the students, and the research was explained verbally along with a brief description of the *research pack*. It was made clear to the students that participation in the research was entirely voluntary and there would be no repercussions for not participating. With the inclusion of the leaflet the students were able to either complete the questionnaire provided (within the research pack) or download and print a copy onto a different coloured paper or participate online.

Website – To assist students with understanding the research and their role in the research, a website (not affiliated to Coventry University) was created that provided further information and participation information. Most importantly, this website included downloadable versions of the information and consent documents for use by participants. For those who wished to participate online, a link to the SONA website (online research recruitment and e-questionnaire system provided by Coventry University) was also provided.

SONA – An online version of the paper-based questionnaire was made available to all students at the university through the SONA system. It is important to note that only students of Coventry University were able to access this site, though it was possible to go directly to the site without visiting the information website (see above).

Word of mouth – Not all of the participants were recruited using the leaflets, website and full cohort talks during lectures. Due to the role of the pilot and the possibility of low participation it was deemed necessary to talk to students who would be willing to participate in the research. Although this method would not necessarily provide a sample that was representative of non-mathematics students across any particular subject, it provided the opportunity to trial the instruments and obtain feedback that could be used to improve the clarity of the instruments prior to the research carried out during 2008/2009. Using this method, students studying mathematics and psychology were invited to participate in the research (note that these students were not all 1st year students). This method of recruitment was only used in the pilot study due to the risk of sampling biases.

Questionnaire placement in the Maths Support Centre – A number of questionnaires (including leaflet, information and consent documents) were left in the centre together with a drop box for students who chose to read about the research and possibly participate.

4.2.4 *Ethical considerations*

Consideration was made for the safety and protection of all participants in all of the studies that were carried out. The students involved were interviewed in a non-threatening environment such as a seminar room. No physical risks were anticipated or encountered for either the interviewer or students. Personal details were not used in any report about the research. Interviews were recorded to assist in the analysis but these recordings were held securely in a locked cabinet and the data they contained were only used for the purposes of this research. Prior to carrying out the research ethical clearance was obtained from the university; after which the ethical procedures outlined by the university were adhered to. Only members of the research team had access to the completed questionnaires and recordings. Raw data relating to individuals was kept for no longer than was necessary in order to complete the analysis and dissemination of the research. All results were reported in a way that preserved confidentiality. Consent forms and raw data were stored in locked cabinets in separate locations. Importantly, informed consent was obtained from all participants prior to participating in the studies. All participants were informed of their right to withdraw at any point during their participation. After all of the studies the participants were debriefed and given full details of the purposes of the studies and the opportunity to feedback their experiences on the participation process.

Not all of the students were given instructions to construct implementation intentions. Moreover as Study 2 ran over one academic year, the students who were not in the treatment group did not have the opportunity to create these plans during their first year of study. However, the treatment was a supplement to support they may already be receiving. In light of this there was not a significant ethical issue regarding students who do not receive the treatment. Furthermore, the lecturers involved in the teaching of the students from control groups were at their discretion able to choose whether to introduce the treatment with their students after the data collection had ended. A short summary of the results and outcomes were made available to all students and staff who participated in the research; students then were able to make their own evaluations regarding the usefulness and value of implementation intentions.

4.3 The Pilot Study

Prior to carrying out the main study, a pilot study was carried out to trial the first versions of the instruments developed for measuring mathematical ability, study habits and demographic data. Through the trialling of the instruments it was possible to inform the development of the instruments as used in future studies. This ensured that any problems originating from question items and instruments that were not pre-constructed could be identified and where possible attempts made to rectify and reduce the weaknesses of those instruments. However, that was not the sole purpose of the pilot, as it also piloted the process of recruiting students (see Section 4.2.3 and Appendices 2.14-2.1.5) who would volunteer to participate in the research.

Being able to recruit a sufficiently large number of participants that was also representative of the wider body of students was an important factor to consider, as were issues of sample size that might reduce the ability to draw statistically significant results from the data due to N being small. Piloting therefore aimed to refine both the recruitment process and the instruments that would be administered to the participants in the next academic year. As a consequence of the pilot it was also possible to explore which recruitment strategies would be best utilised for maximising the number of participants.

In the pilot and subsequent studies one of the aims was to control and take into account the effects of social desirability. For the studies detailed in this thesis the Marlowe Crowne Social Desirabilty Scale (Crowne and Marlowe 1960) was used as it is a well known and commonly used instrument for measuring social desirability. The Marlowe Crowne Social Desirability Scale consists of 33 items (agree or disagree responses). The instrument is used to ascertain participants' willingness to please or displease the researcher (i.e. to beat the test or seek approval/praise) e.g. under or over estimates of the amount of time spent engaged with mathematical study outside of formal lectures or responses to personality inventories. It was deemed important to check for social desirability due to the large number of self-report measures being used in the pilot and also subsequent studies described in this thesis.

Furthermore, this pilot also gave the opportunity to conduct preliminary analyses on the data to consider whether there were differences between subject groups in mathematical ability and to identify any differences between intended study behaviours and actual study behaviours. These questions were answered by testing the hypotheses that a) There exists a difference in mathematical ability between different subject groups and that b) Intended study behaviours are different from actual study behaviours (Sniehotta et al. 2005, Kirner et al. 2006).

4.3.1 Method

4.3.1.1 Participants

As the overarching aim of the research outlined in this thesis was to improve the usage of support services by students from non-mathematical subjects, the target population from which the pilot sample was drawn reflected this. However, the composition of the pilot sample was heavily influenced by the recruitment process and the availability of potential participants. Using a combination of recruitment strategies (see Section 4.2.3), it was anticipated that the sample would contain a mixture of the following students:

- Nursing students (direct contact with students + leaflets/flyer)

- Students from a variety of Disciplines (word of mouth, questionnaire placement in the Mathematics Support Centre),
- Psychology students (word of mouth, website + online questionnaire)
- Other students (leaflets and posters placed in the library)

A total of 28 participants volunteered to participate in the pilot from Mathematics (10 male, 5 female), Nursing (4 female) and Psychology (9 female).

4.3.1.2 Materials

For the intervention studies (Studies 2 and 3) a number of variables were being measured through the use of either pre-existing or newly constructed instruments. Table 4.2 summarises the variables that were being measured across the studies and the instruments used to measure them.

Table 4.2: Summary of the instruments and variables

Measure	Instrument Used (Questionnaires)	Newly Constructed	Used in Pilot Study?
Demographics	Demographics	Yes	Yes
Mathematical ability	Mathematics Diagnostic	Yes	Yes
Social desirability	Marlowe Crowne	No	Yes
Mathematical Study Behaviour	Mathematics Study Behaviours	Yes	Yes
Personality (extroversion and psychoticism)	EPQ-R	No	No

For the purposes of the pilot it was necessary to focus on only those instruments that were not already in use or had not been used in the past as it was assumed that these were most likely to need amending and improving after the pilot work had concluded. During the pilot students were asked to complete a questionnaire that included the Demographics Questionnaire (see Appendix 2.11 for Version A), Study Behaviour Questionnaire (see Appendix 2.5, Version A), Mathematics Diagnostic Questionnaire (see Appendix 2.2, Version A) in addition to the Marlowe Crowne social desirability Scale.

Demographics. The Demographics Questionnaire consisted of ten items that asked students to provide information relating to their age, gender, mathematics qualifications on entry (year attained and qualification type) and their current studies (course, year and mode of study).

Study Behaviours. The aim of this study was to trial a self-report instrument for measuring the amount of time spent engaged with mathematical study outside of formal lectures. No standard measure of study behaviours (intended and actual) could be found.

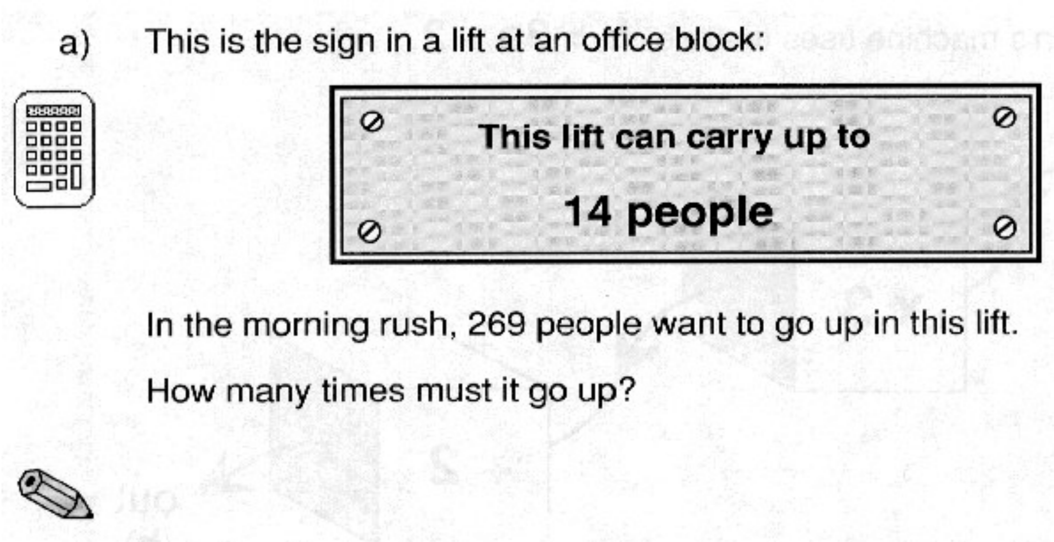
The aim of the questionnaire was to ascertain both the intended and actual number of hours students used the Mathematics Support Centre. It was acknowledged that students could engage with learning in many different locations and times that did not necessarily involve the University provided support provision. In constructing the study behaviours instrument the main aim was to include items that would allow the majority, if not all forms of mathematical study to be recorded. The instrument used to measure the study behaviours of students during the pilot intended to ascertain both actual and intended study behaviours within the same instrument.

The questions within the instrument were split into two sections: one for intended behaviours and one for actual behaviours. Both sections included one table where participants could record the approximate number of hours that they spend studying using a number of strategies and locations for learning (either intended or actual) during a period of one month. Each section also included several question items related to their study habits (either intended or actual). During the construction of the table it was necessary to make it comprehensive and also free from unnecessary complexity. The main problem encountered was the fact that strategies or methods of studying could be carried out in several different locations. To collect a detailed record of the mathematical study habits would have required a grid with various locations along the rows and the types of activity along the columns. Participants would have to add the number of hours they intended to spend engaging with different study behaviours in each location (then repeat this for their actual behaviours). This was judged to be overly complicated as students may not be likely to remember exactly how many hours they spent engaged with activity 'X' in location 'Y' in the past month. To simplify the table a list of behaviours or locations was constructed and students were asked to write down how many hours they engaged (or intended to engage) with each. The other question items were intended to help the students focus on the task of remembering their study habits by thinking about when they studied and what they knew of the support services on offer by the university. The initial version of the Study Behaviours Questionnaire can be found in Appendix 2.5.

Mathematics Ability. All students who participated in the study were required to have at least a GCSE or equivalent qualification. A number of universities have found that the increasing diversity of entrance qualifications combined with the varying times between achieving the qualification and enrolment on the course has meant that past qualifications are a poor measure of mathematical ability on entry (LTSN MathsTeam Project, 2003b). The report by LTSN MathsTeam Project (2003b) highlights the use of diagnostic testing (and appropriate feedback) on entry as a more accurate measure of ability and as a means to support students in improving their mathematics skills. Mathematical ability was measured using a 7-item scale (see Appendix 2.2), which consisted of questions relating to arithmetic, unit conversions, percentages and ratios. Individual question items used in the pilot were based upon a pre-existing mathematics diagnostic test used by the Faculty of Engineering and Computing at Coventry University. The questions used in the pilot were based on those that would be suitable for students without an A-level or equivalent qualifications in mathematics.

Either contextualised or non-contextualised questions could have been used to assess the mathematical ability of students. Contextualised mathematics questions are those that are set within a real life or some other believable context. Examples of this could include numeracy questions relating to subtraction and addition set in the context of a supermarket. Students could typically be given a price list and asked to work out the total cost of the goods on a shopping list followed by change received from a £10 note. Abstract problems are devoid of any meaningful link to a situation or context e.g. 1.99 + 2.49 - 1.09 = ? and 10 – (1.99 + 2.49 + 1.09). In a typical contextualised mathematics problem the student could attempt to use the context to further define the problem, in which case the learner may add and create unnecessary and potentially incorrect inferences about the problem that needs to be solved. An example of this could be that of the lift question (from SEAC 1992 in Cooper 1996) shown in Figure 4.1 (below).

Figure 4.1: Example of a typical contextual mathematics question



Students could argue that 14 people would not fit in a lift and that the maximum number of people that could realistically fit inside is 8. This interpretation would result in an incorrect answer according to the marking scheme. The difference between students' interpretations and the correct interpretation intended could result in a different question being answered. However, from the student's viewpoint all information has been used correctly, i.e.:

- Personal experience suggests that lifts do not tend to be designed such that they can carry the maximum number of people stated
- The question supports the above 'fact' by stating "This lift can carry ***up to*** 14 people"
- In no part of the question does it state that the lift must be full before moving

Based on the addition of new 'facts' to the problem, the student may write down the answer to "269 divided by 8" rather than "269 divided by 14". Boaler (1993) suggested that contextual questions which are familiar to the learner are those that the learner may well become more engaged with and as such introduce properties and experiences they know of about the context to the problem and as a result perform worse.

Although the use of contextualised questions would have allowed problems to be set in a context that would be deemed relevant within the subject areas of the students, a number of problems were foreseen that could have had implications on the analysis of the data and how participants interpreted the questions. Using context dependent questions would have required either identifying a context that all participants were familiar with or creating different context specific questions for students based on their chosen university course of study. In both cases the participants may have been subject to contextual bias in the methods by which they chose to answer a question (see Figure 4.1 above). Furthermore, the analysis (comparisons between students from different courses) could become problematic as the questions being answered had been set in different contexts. By choosing to make each question item in this instrument as abstract as possible, contextual effects that may influence participants' performance either through the way in which the question is seen or perceived (Mevarech and Stern 1997) or through contextually dependent procedures for solving mathematics problems (Boaler 1993, Cooper 1996) were reduced. The intention was to reduce as far possible the probability of students using prior knowledge of the context of the question and thus inadvertently answering a different question from that which was being set. Furthermore, Van den Heuvel-Panhuizen (2005: 5) describes this occurrence as follows:

> In the word problem the reality that is presented is often not in tune with the real situation… In this word problem, the context reflects the world of textbooks. In this world, there is little space for reality with its unsolvable and multi-solvable problems.

This suggests that it may not be wise to assess the students using contextualised questions. However, Clausen-May and Vappula (2005) present evidence that suggests learners do not find difficulties in transferring abstract mathematical skills to problems set in different contexts. For this research the aim is not to transfer knowledge they may have into a new context, but rather to test their mathematical ability not their ability to transfer knowledge from one context to another. For this reason abstract questions were used in the diagnostic test rather than course specific contextualised questions. The Faculty of Engineering and Computing diagnostic tests comprised of a lengthy set of items that would take students with a mathematical background (A-level mathematics) up to one hour to complete. However, students that were to be involved in the research project would not necessarily have an A-level or equivalent in mathematics. Consequently Version A of the diagnostic test (see Appendix 2.2) used in the Pilot study included questions relating to multiplication, division, ratio, percentages and unit conversion. These topics were picked as they generally covered many of the basic numeracy requirements for students engaged with courses not requiring an A-level mathematics or equivalent qualification on entry.

Social desirability. As indicated in Section 4.3, there was the possibility that participants might respond to question items within the questionnaires in a manner they perceived to be socially desirable. To explore the effect of social desirability on participants' responses on the three instruments being trialled, they were supplemented by the Marlowe Crowne Questionnaire (see Appendix 2.8). Social desirability was measured using the Marlowe Crowne Social Desirability Scale (MCSDS; Marlowe and Crowne 1960) to ascertain the participants' tendency to appear more socially acceptable to those whose opinions are felt to be important (e.g. peers, researchers). Due to social desirability being a known source of bias in self-report studies (Parkes 1980), the measure was included here so that the extent of socially desirable responding could be factored into any analysis of the data, therefore overcoming one of the criticisms of self-report based research (Crowne and Marlowe 1960, Razavi 2000). In the case of study behaviours, a correlation between self-reported study behaviours (Section 4.4.4) and social desirability would indicate that there may be a tendency to over-inflate or under-report their usage. This inflation or under reporting could be due to the student wanting to either appear:

- More studious (inflated reports)
- Trying to suggest they are not weak in mathematics (under reporting)
- Trying to please or displease the researcher (giving overly exaggerated usage measures or not reporting any usage)

4.3.1.3 Procedure

The administration of the instruments varied between participants based on the method chosen to complete the questionnaires and also the recruitment strategy used to recruit individual participants. These variations also influenced how completed questionnaires were retrieved once participants had answered the question items.

Paper-based questionnaire – For those who completed the paper version, four slightly different options were available as a method by which the questionnaire could be completed. By making several methods available to the participants, it was possible to observe which method was most effective:

- Given the questionnaire in a lecture (direct contact with students + leaflets) – participants would take the questionnaire and information sheet away from the lecture theatre and decide if they wished to participate or not. If they wished to participate, the participant would be able to complete the questionnaire and consent form, which could then be returned via a designated drop box located in the university.
- Given the questionnaire outside of a formal lecture (word of mouth) – participants would be given the questionnaire and would have the option to complete the questionnaire and consent form either immediately or return the documents to the researcher at some later time (not necessarily via a drop box).

- Participants who downloaded the questionnaire would print out and complete the documents after reading the information and consent information. Participants would then have had to return the questionnaire via the drop box.

- Participants were also able to return completed questionnaires directly to the researcher as contact details including office location were provided on the participant information sheet.

Online questionnaire – Access to the online questionnaire was a second method by which participants were able to access the questionnaire. This method ensured that only Coventry University students were completing the questionnaire. As with the paper questionnaire, all participants were able to read information about the research and the relevant ethical precautions taken by the researcher to ensure anonymity and data protection. Sufficient information was made available in the questionnaire instruction so that participants were able to make an informed decision. It was made clear to them in the instructions that proceeding further and answering subsequent questions would be taken to mean that they had agreed and consented to participation and were happy for the data to be used for research. Those taking the online questionnaire as discussed before could access the SONA system either directly or by following the link on the research information site. In both situations students would need to register for an account before being able to proceed. For students on the Psychology degree there was an added incentive for participation via SONA as doing so enabled those students to automatically accrue course credit. Unfortunately this course credit by research participation was only available for psychology students. Data from SONA was stored in an online database and was available for retrieval in either .XLS or .CSV type files.

All participants were given the option of completing the paper-based questionnaire (either given to the student or downloaded and printed from a website) or online through the SONA system. The recruitment strategies and methods for returning completed questionnaires resulted in 28 volunteers who participated in the study. Of the 28 participants, 24 (15 mathematics students and 9 psychology) were recruited through word of mouth while 4 (nursing students) were recruited by direct contact within a nursing lecture. In all cases the participants chose to return the questionnaires directly to the researcher. Participants did not have the opportunity to complete questionnaires immediately when they were recruited within a lecture (all nursing students chose to return the completed questionnaires directly to the researcher), whereas those recruited by word of mouth were able to complete the questionnaire immediately if they wished (the majority chose this option, only 3 chose to return the questionnaire at a later date).

Participants were debriefed and reminded of their right to withdraw their data, the steps taken to ensure anonymity and also the full details of the research and its purpose. As part of the debriefing, participants were given the opportunity to reflect on the experience and provide feedback to the researcher where possible about their experiences and feelings towards the recruitment process, questionnaire instruments, question items, improvements that could be made to the instruments and process as a whole and the clarity and transparency of the research.

4.3.2 Results

Data were collected from all of the participants, however, complete data were only available for 26 out of the 27 participants. The data collected from the Pilot study are summarised in Table 4.3 below.

Table 4.3: Pilot data results for students studying Mathematics, Nursing and Psychology

Course		Male	Female	Mathematics diagnostic score	Intended study***	Actual study**	Social desirability
Mathematics	Mean	10*	5	6.50,	160.21,	101.96,	18.07,
N = 14	Median			7.00	118.50	95.00	19.00
	(SD)			(0.76)	(109.98)	(65.39)	(3.91)
Nursing	Mean,	0	4	5.75,	9.75,	4.50,	15.50,
N = 4	Median			6.00	10.00	4.25	16.00
	(SD)			(1.26)	(1.26)	(0.71)	(3.7)
Psychology	Mean,	0	9	4.89,	66.89,	44.44,	10.56,
N = 9	Median			5.00	52.00	42.00	10.00
	(SD)			(1.45)	(41.82)	(39.03)	(3.78)
All Courses	Mean,	9	18	5.85,	106.81,	68.35,	15.19,
N = 27	Median			6.00	94.00	53.00	14.00
	(SD)			(1.29)	(100.61)	(63.56)	(5.05)

N.B. Due to the sample sizes of the sub groups being small the standard deviations given have little meaning, they are only quoted for completeness.

*Though 10 male participants responded only 9 provided complete data for

**Amount of time (hours) participants intended to study mathematics over the coming month

***Total time (hours) spent studying mathematics over the over the past month

(hours)

Data from Table 4.3 suggests that for all participants the number of hours that participants intended to study over the coming month was greater than the actual number of hours studied over the previous month. Furthermore, there appeared to be differences in the means of the mathematics diagnostic scores, intended study and actual study between the subject groups suggesting that students from different course groups may have differing mathematical abilities. Although the difference in mean scores between the groups was only 1.61 (difference in medians was 2), the standard deviation of scores on the mathematics scores for students studying mathematics was small (0.76) and suggests that there is likely a ceiling effect as the majority of participants in that group scored the maximum score of 7 out of 7. Importantly, this also suggested that the instrument, while being useful for students from non-mathematical backgrounds, may well be inappropriate at differentiating mathematics students based on mathematical ability. Differences between social desirability scores were also observed between groups. However, these differences alone do not suggest that there is a correlation between social desirability and other variables used within the pilot.

4.3.3 Summary of the Pilot study

It is important to understand that the aim of the pilot study was not to ascertain whether there was a difference in intended and actual study behaviours but to improve the test instruments and to reduce ceiling (and floor) effects that may be inherent in some of the instruments (i.e. mathematics ability and usage). For instrument development the pilot was able to provide some insight into the limitations of the instruments and how these might be reduced. It should be noted that during the pilot no financial or material incentive was made available to induce students to participate as it was felt that this kind of incentive would not have been equally attractive to all students and thus increase the risk of a biased sample.

The pilot aimed to trial a number of participant recruitment strategies. Using those strategies it was found that the response rate was very low (below 5%). For the purposes of this research this would have proved unacceptable due to the minimum sample size required for meaningful statistical analysis to be carried out. In light of the pilot data a number of improvements were planned for use in the intervention studies both in terms of recruitment and the instruments that were used.

The pilot study allowed for many issues regarding length and clarity of the instruments to be identified and remedied. The improvements of the instruments are discussed in Sections 4.4 and 4.5 along with examples being given in Appendix 2. This study also highlighted the difficulties that were encountered again in Studies 2 and 3 with regards to recruitment and student attrition.

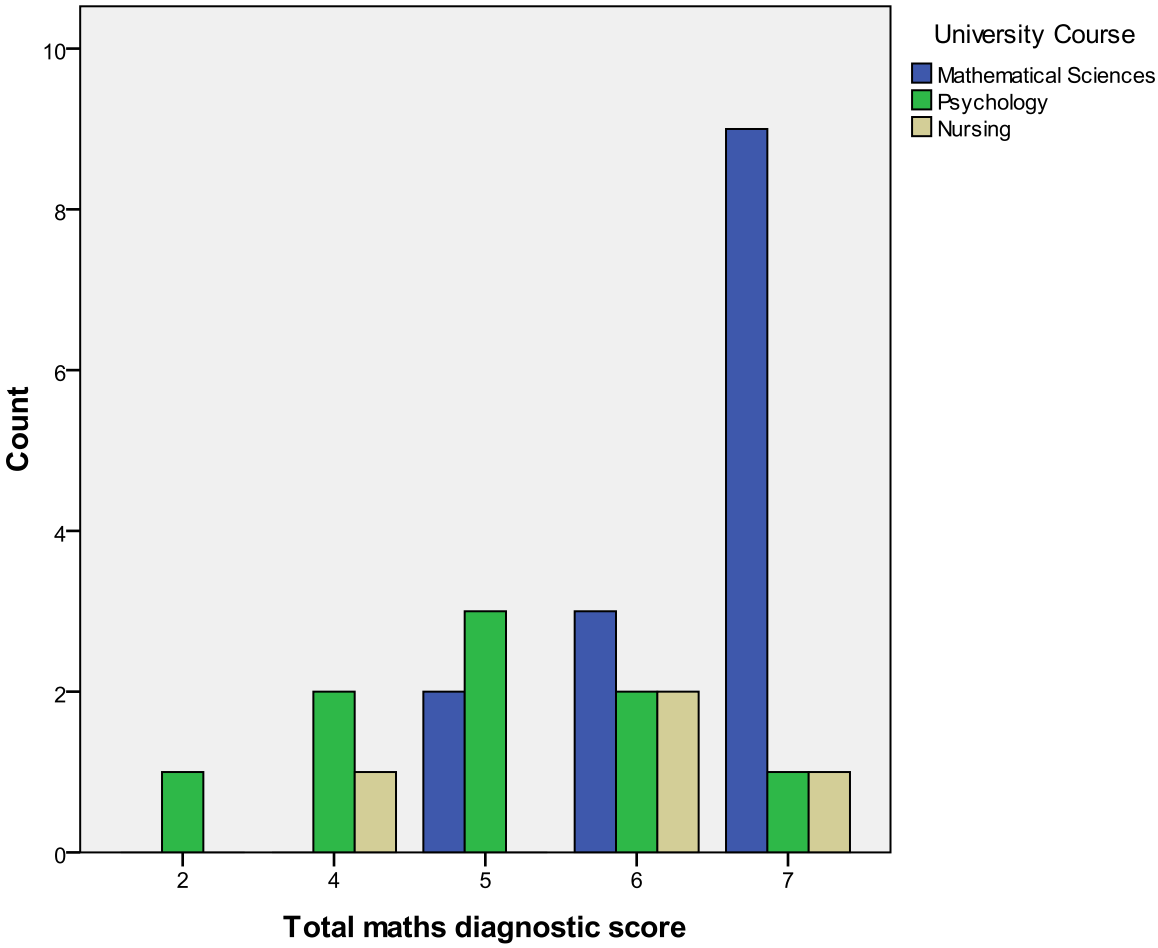
4.4 Analysis and Development of Instruments

During the studies described in this thesis a number of paper-based instruments were used to gather data. This section describes the development and justification of the instruments used in the studies. The primary purpose for carrying out the analysis was to assess the instruments for reliability, validity and clarity of the question items as well as trying to ascertain which methods of recruitment would be most likely to yield the highest number of participants. Where possible the experiences of conducting the pilot study were used to inform the methods used in the subsequent studies.

4.4.1 Development of a Mathematical Ability Assessment

Based on the data obtained from the pilot, the diagnostic questionnaire was not appropriate for all of the students who had taken part in the study. For students on the mathematics course there should have been little to no problem in completing the diagnostic assessment. In the majority of cases this was true, with students obtaining full marks. Only 5 of the 14 mathematics students did not score full marks and only scored 5 or 6 out of a possible 7 (see Figure 4.2 below). However, students from non-mathematical subjects did find the questionnaire more difficult (see Figure 4.2 below). As a result some of the mathematics students did complain about the diagnostic assessment being too easy, and they questioned the relevance of the content to their studies. The perceived lack of difficulty of the assessment by the mathematics students was nothing to be concerned about as the target sample for the studies in this thesis were those who do not necessarily have a GCSE in mathematics.

Figure 4.2: Bar graph showing the distribution of mathematics diagnostic scores across three university courses



As there were a small number of questions, it was likely that there were ceiling effects due to the difficulty and number of questions. This was most apparent for the mathematics students. However, the test was aimed at non-mathematics students and as such the ceiling effect encountered was not as big a problem as would be suggested by the data presented in Figure 4.2.

A review of the diagnostic test (Version A) highlighted a number of areas that were not covered in the initial version, namely transposition of equations, graph reading and the calculation of gradients of a straight line. For both Study 2 and Study 3, three questions were added to the diagnostic test that addressed these topics. These questions were added to the assessment as it was felt students across all of the subjects would be required to make use of these skills (e.g. interpreting graphs of financial data or trends over time, rearranging formula to help calculate the correct number of tablets to give to a patient, working out the rate of increase of a dependent variable for unit increases in a predictor variable.)

It is important to note that the role of the mathematics diagnostic test was only to assess the initial mathematical competency of participants, rather than pre-post test performance as the study was not concerned with evaluating the effectiveness of the Mathematics Support Centres (or any other strategy the participants may have employed). The role of the diagnostic test was to help ascertain if initial mathematical ability was a factor that influenced the usage of the Mathematics Support Centre. As the effectiveness of the Mathematics Support Centre in improving mathematical ability was not of concern to this project, there was no need to administer a mathematics diagnostic test at the start and end of Study 2. However, an assessment of the time taken to complete the test instruments during the design of Study 2 suggested that the post-intervention instruments would take less time to complete than the pre-intervention instruments. This was seen as an opportunity to create a second alternate form of the questionnaire that could be administered at the post intervention stage. At the time of designing Study 2 it was felt that doing so would allow a more reliable instrument to be used should further data be required in a latter study. As the diagnostic test was created for the research it was felt that creating a second form of the test and administering it would help in the process of developing a more reliable instrument for Study 3. Examples of the two alternate versions of the questionnaire that were used in Study 2 (Versions B and C) can be found in Appendices 2.3 and 2.4. During the design of Study 3 it was found that the total time taken for completing the test battery was too long. Several students gave feedback during the debriefing that suggested a shorter instrument might be better to keep them interested and not "put them off". The overall length could have contributed to the high level of participant attrition and incomplete responses (refer to chapters 5 and 6 for further detail). Due to the requirement for a shorter set of instruments, there was time to include one version of the mathematics diagnostic in Study 3. Internal reliability of the instruments was calculated using Kuder-Richardson's rho (in place of Cronbach's alpha due to dichotomous question items) using formula 20 (as not all of the question items were assumed to be equally difficult). Rho was calculated for each version of the diagnostic test, version A = 0.609, version B = 0.660 and version C = 0.713 (Study 2) & 0.716 (Study 3). Due to the higher reliability of Version C during Study 2, it was chosen again for use in Study 3 (Version C, see Appendix 2.4).

4.4.2 Assessment of Social Desirability

During the debriefing of participants who had taken part in the Pilot Study, one question item was found to have caused problems for approximately 10 of the participants. The question item of concern was item 25 which asked “I have never been irked when people expressed ideas very different from my own.” The students did not understand the meaning of the word “irked” and as a result were not able to answer the question properly. Students reported that they had either guessed an answer or picked one at random.

The initial confusion caused by the word ‘irked’ was reduced by rephrasing the question item into “I have never been irritated or vexed when people expressed ideas very different from my own.” for studies 2 and 3. This replacement of the work ‘irked’ was found to eliminate the only word where students were not sure of the meaning. An example of the Marlowe Crowne Social Desirability Scale is shown in Appendix 2.8 (this version includes the amended item 25).

4.4.3 Personality

The role of personality on the behaviours (see Section 3.2) and achievements (see Section 3.1) of students was discussed earlier in Chapter 3. It was suggested that measuring extroversion could help in explaining the levels of Mathematics Support Centre usage due to the collaborative learning experiences that the services tend to facilitate. psychoticism and conscientiousness were highlighted as possible factors that could explain the effectiveness of implementation intentions. The literature suggests that personality could impact on the effectiveness of the interventions outlined in Studies 2 and 3, as a result it was decided to focus on the measurement of both extraversion and psychoticism.

A number of instruments for measuring personality were described in Section 3.3. The decision of which instrument to use in this research was a difficult one as it was necessary to consider the length, type of response (dichotomous or Likert) and the personality facets being measured by each instrument. For the research that was carried out, a shorter personality scale was required for practical reasons; namely to keep the time required to complete the instrument to a minimum as the questionnaire comprised other instruments in addition to the personality assessment. However, the instrument was also required to measure psychoticism and extraversion adequately.

Research has suggested that conscientious can moderate the effectiveness of implementation intentions (Webb 2007). The research proposed in this thesis aimed to measure psychoticism, extraversion and neuroticism using the EPQ (Eysenck and Eysenck 1975) with a focus on the psychoticism and extraversion for two main reasons. Firstly, the activities that were being promoted through the formation of implementation intentions were considered group activities, many students use the Mathematics Support Centre as a place to work with their peers. Since psychoticism and extraversion can be used to assess the tendencies of individuals to prefer individual or group based work, those measures were chosen rather than conscientiousness. Secondly, Looking at the number of test instruments students had to complete combined with the need to keep each testing session well within 1 hour in length, the EPQ-R instrument was chosen because it was less time consuming to complete than the NEO PI-R (Costa and McCrae 1985) instrument. It was decided to choose the 106 item Revised Eysenck Personality Questionnaire (Eysenck et al. 1985) as it adequately measured the extraversion and psychoticism personality traits which were of primary interest and was also a relatively short and simple instrument (106 questions where participants respond with either “Yes” or “No” responses) compared to other instruments such as the Revised NEO Personality Inventory (consisting of 240 question items on a 5 point scale) or the Minnesota Multiphasic Personality Inventory, MMPI-2 (567 items).

The EPQ-R assessed participants on six subscales: psychoticism (scores ranging from 0 to 32), extraversion (0 to 23), neuroticism (0 to 24), lie (0 to 21), addiction (0 to 32), criminality (0 to 34). Each question item of the 106 items in this instrument was answered with either as ‘Yes’ or ‘No’ responses. The EPQ-R measures several other personality facets in addition to extraversion and psychoticism. The question items measuring each facet were not distinct from questions measuring other facets. Furthermore, the items measuring the lie, addiction and criminality subscales were explicitly mentioned in the test manual as being constructed using items from the extraversion, psychoticism and neuroticism scale items. When administering the EPQ-R it was decided that all question items would be kept when administering the test to ensure that there was no unexpected effects on the responses due to the removal of question items. The reduction in the number of question items achieved by using items only required for the extraversion and psychoticism scale was not felt to be great enough to justify the risks associated with modifying the instrument.

Using the EPQ-R instrument in this thesis, psychoticism was thought of as a personality trait that measures the tendency of an individual (high scorer) to behave in a manner that suggests the inability to ‘fit in’ and a preference for more solitary behaviour (Eysenck and Eysenck 1991: 6). Similarly, extraversion is a measure of an individual’s tendency to be concerned with issues outside of the self and the need to seek out stimulus and enjoyment through engagement and interactions with others (Eysenck and Eysenck 1991: 4). Finally Neuroticism can be described as an individual’s tendency to worry or be overly concerned about any number of situations (Eysenck and Eysenck 1991: 4).

It is important to note that the psychoticism and extroversion/introversion (along with neuroticism) scales as measured using the EPQ-R are used as descriptors of the general population with normal, non-pathological behaviours (i.e. not scoring nearing the maximum or minimum of the scales).

4.4.4 Mathematical Study Behaviours

The main focus of the studies described in this thesis was to ascertain if an intervention based on implementation intentions could increase the number of hours spent engaged with mathematical study outside of formal lessons. The study behaviours questionnaire was developed to quantify the amount of time spent engaged with various study-related behaviours including the use of the Mathematics Support Centre. Furthermore, for the purposes of this thesis, aspirations to study as used in Versions B and C (see Appendix 2.6 and 2.7) of the questionnaire were considered to be the same as participants' behavioural intentions towards study. The change in the amount of time spent engaged in mathematical study was calculated by comparing the scores obtained from the instrument at pre-intervention and post-intervention times. Each version aimed to gather data both on an individual's actual study behaviours and his/her intended study behaviours.

Version A (see Appendix 2.5) was constructed during the initial piloting phase (Study 1) and aimed to gather study behaviour data focusing on the number of hours spent studying mathematics (actual and intended) together with question items relating to patterns of study behaviours i.e. at what times of year does study occur the most. Generally the feedback obtained during the debriefing suggested that Version A was both too long and overly wordy. Some participants also commented on the perceived complexity of the questionnaire, again making reference to the length and number of question items. However, there was a preference for boxes that could be ticked or small tables that could be completed (though only if these were simple and not confusing). Some of the statements given by students during the debriefing can be seen below.

- "The questionnaire is too long"
- "I don't understand why we are answering the same questions twice"
- "You've repeated the questions for no reason"
- "It's confusing"
- "It's a bit difficult to answer, we spend so much time in here and I think it is hard to exactly say how many hours we spend studying maths"

From the debriefing the major concern was the length of the questionnaire and the perceived repetitiveness. Though the questions on intended behaviours and actual behaviours were different, participants indicated that at times it felt that they were answering the same question twice. Furthermore, the length of the questionnaire was regarded as being a negative feature of the instrument. It was suggested by participants that other students may not have as much time to spare for participation in the study and could have left the questions blank. As with the mathematics diagnostic test, there was a possible limit imposed on the range of answers that could be given (e.g. the number of hours engaged with mathematical study). Although the upper limit was potentially approximately 360 hours (if an individual studied 12 hours per day for 30 days), it was unlikely that students in any discipline would approach this limit. However, the lower limit of zero hours of study was possible and resulted in responses on usage having a lower bound. Though it was not possible to change this, it could have had implications for analysis of data in the main studies (such as when looking at difference scores). Based on the feedback on the Pilot Study, improvements were made to the instrument such that the study behaviours section was shortened with increased clarity (see below).

Version B (see Appendix 2.6) was therefore constructed using feedback from participants on the question items contained in Version A. The list of questions was removed and replaced with a small table split into two sections (left and right) as shown in Appendix 2.6, and questions pertaining to patterns of study were also omitted. On the left hand side, a grid was constructed such that each row represented a different activity and each column a different location; a tick in the grid suggests that the activity indicated by the row is performed in the location indicated by the column. The aim of the left hand side of the grid was to assist the participants in thinking about *where* they engage in specific mathematics learning activities. By actively thinking about the locations where they had studied, it was envisaged that the participants would be able to more accurately complete the right hand side of the grid indicating the amount of time spent studying. A participant would tick as many grid squares as necessary to indicate where they engaged in the learning activities. On the right hand side of the table participants indicated their study behaviours by writing down three numbers (actual, aspirational, estimate) relating to the *number of hours* engaged in each of the six mathematics study related activities. For each activity the questionnaire assessed three variables:

Actual – The number of hours that study activity X was engaged with over the *previous* month. This is thus based on the students' perception and recollection of how many hours that were spent performing activity X in the different locations.

Aspirational – The number of hours an individual would like to perform activity X over the *next* month. The aspirational number is based on how often the individual would aspire to study. This measure was thought of as the participant's intention to study in the specific location.

Estimated – This last estimate of usage is based on the individual's perception of their own tendencies and past performances of the activity. It is the individual's estimate of how many hours would be spent engaged in activity X knowing that their own personal barriers and their possible commitments.

Version C (see Appendix 2.7) was similar to Version B in that it required participants to estimate their actual, aspirational and estimated number of hours spent studying.

However where Version B allowed participants to indicate where the study behaviour was taking place, Version C required participants to only indicate how many hours that were spent receiving support or studying in a Mathematics Support Centre.

4.4.5 *Intervention Materials*

In Section 4.2.1 a number of design issues related to intervention studies were highlighted. These related to contamination, allocation to conditions and assumptions of baseline measures. The development of the intervention (both treatment and control) was influenced by the design considerations introduced in Section 4.2.1. Contamination of participants from different conditions was of greatest concern and as such influenced how participants were allocated to conditions. During the planning stages of the study it was not possible to ascertain or assume the logistical practicalities of how random allocation would occur. However, preliminary discussions with lecturers involved with the teaching of courses where participants were recruited from indicated that moving participants within a lecture theatre would be unrealistic as it would both waste time and be impractical due to the limited space available. In light of this students were not moved around the workshops or lecture theatres. A better solution was considered to be the random allocation of rows within the lecture theatres to either control or treatment conditions. This would remove the amount of contamination that might occur within rows of students but not between rows. It was also highlighted in Section 4.2.1 that ideally participants should not be aware which condition they had been allocated to.

The random allocation of rows to condition rather than individual participants assisted with this.

To further hide which condition each participant had been allocated to it was necessary to ensure that the length of the interventions (treatment and control) were approximately the same length (1 printed page) and took approximately the same amount of time to complete. Keeping the length of the task equal helped to reduce participants' perception that the two tasks were different. Had the tasks been of differing lengths then it is possible that some students may have wished to swap their questionnaire with another student in order to complete it more quickly. Furthermore, ensuring that both tasks took approximately the same amount of time to complete would help reduce participants of one condition completing their assigned task more quickly than those in the other condition. Ensuring that the time required to complete the questionnaires were approximately equal also reduced the risk of alerting students to the fact that they had been allocated to one of two differing conditions.

In light of the above considerations, it was necessary to create a treatment task that was self-contained and did not require extra verbal guidance from the researcher. A study by Webb (2007) looking at class attendance was carried out by giving participants one of two versions of a questionnaire. Those in the treatment conditions had written instructions on how to form implementation intentions appended to the end of the questionnaire in the form 'We want you to plan to attend lectures over the next 2 weeks. You are free to choose how you will do this, but we want you to formulate your plan in as much detail as possible. Please pay particular attention to the situations in which you will implement these plans'. Those participants in the control conditions were given no such instructions. The interventions used in Studies 2 and 3 aimed to use written instructions to aid the creation of implementation intentions. However, unlike the instructions used by Webb (2007), the instructions used in the studies were more structured and contained a series of four tasks. To do this, full instructions of how to form the implementation intentions were given in the form of short tasks. Tasks required the participant to write down the components used to form implementation intentions and then a final task that through an example helped participants to construct an implementation intention using the components. The treatment task consisted of 4 small tasks. Tasks 1 and 2 aimed to encourage the student to identify barriers to their learning and strategies to improve their mathematical skills. Task 3 required the participants to write down why they should improve their mathematics (based on these answers from Task 1 and 2) in addition to when and where they could improve their mathematical ability. Lastly, Task 4 required the answer from Task 3 to be constructed into a sentence that is the implementation intention. Furthermore, Task 4 required the participants to copy the implementation intention out two more times and then read the sentence in their head two more times. This is similar to the strategy used by McDaniel and Scullin (2010). Task 4 as used in Study 2 can be seen below:

Task 4

You are now going to construct a plan that describes how you are going to accomplish the activity or way of improving your mathematics that you circled in **Task 2** by describing when and/or where you plan to carry out the activity. The plan should look similar to one of the example shown below:

> "If [*Why would you?*] and [*When or Where would you?*] then [*Activity circled in Task 2*]"
>
> "If [e.g. I have a problem with maths] and [e.g. *it is Wednesday*] then [e.g. *I will go to the support centre*]"

Write down your plan below:

- ____

Copy your plan 2 more times

1. ____
2. ____

In addition to this it was decided prior to carrying out the studies that simply replicating the treatment task and omitting the final task was risky as there was no way to be sure that participants would or would not construct implementation intentions on their own after having written down the components. A mathematical task that did not relate to the mathematics that the participants were likely to engage with during the course whilst also being accessible to all of them was constructed. A summary of the instruments is given below, with examples of each given in Appendices 2.9 and 2.10.

Participants were given one of two tasks based on which condition they had been allocated to. Each task was no longer than 1 side of A4 paper in length (including space for participant's answers). Those in the control group received a task that asked for their feelings and descriptions of infinity through prose and drawings. The task was chosen due to the content having both mathematical and non-mathematical meanings. All students were able to engage with the task regardless of their own mathematical ability. Furthermore, all students will have some perception of what infinity could mean either in the form of an endlessly repeating process, mathematics or from religious beliefs. An example of Version A of the control task can be found in Appendix 2.9. Those in the treatment condition were given a task that assisted the participant in forming an implementation intention that aimed to promote behaviours related to studying mathematics. Two versions were created (Version A in Appendix 2.9 and Version B in Appendix 2.10).

Version A (used in Study 2) focused on an intervention that would facilitate the formation of implementation intentions relating to study behaviours in any location (i.e. home, library, parks etc.). As such the tasks asked participants to identify examples of personal obstacles to studying, strategies to overcome these study related obstacles and then identification of times and places where these strategies could be employed. After this, the participants were asked to form implementation intentions (guidance given) based on their identification of obstacles, strategies and where/when the strategies could be carried out.

Version B (used in Study 3), aimed to be more specific in the behaviours being promoted using implementation intentions. Rather than asking participants to form plans aimed at promoting general mathematics study outside of taught lectures and workshops, the aim was to focus on behaviours involving the Mathematics Support Centre.

4.5 ANALYSIS AND DEVELOPMENT OF RECRUITMENT AND ADMINISTRATION STRATEGIES

4.5.1 RECRUITMENT

A number of methods were used during the Pilot Study to recruit participants into the research. However, in many cases these were ineffective. Despite the use of the various techniques, the number of responses was very small. It should be mentioned that even where direct access to a whole cohort (nurses) was available through a 10-minute presentation at the beginning of a lecture in addition to the entire cohort being given a questionnaire each, the proportion of returned questionnaires was less than 4%.

Based on this it was decided to take a more proactive approach when carrying out the intervention studies. The approach used was to seek out the co-operation of tutors and lecturers in various departments throughout the university. This was firstly necessary to ensure that access to students was possible at pre, post and intervention stages of the study. Furthermore, it was necessary to ensure that a greater proportion of the students volunteered to participate in research.

As a result of the Pilot Study, the intervention studies were organised such that where possible, a short session was appended to a timetabled workshop or lecture. All students who then attended the lecture would be informed of the research and the associated benefits. Each student would then be in a position to make an informed decision as to whether to participate or not and give informed consent. Those who wished to participate could stay, while those who opted to not participate could leave the session. However, it is important to note that even though all students would receive information on the research and an invitation to participate within the timetabled lecture or seminar, there was still no obligation to volunteer. All students were informed of the voluntary nature of participation in addition to how they may withdraw.

4.5.2 Administering the Instruments

Questionnaire type paper or online - During the piloting phase students were given the option to complete the test instruments online (a user account was created by each participating student). This did allow the participants to complete the questionnaires at a physical location of their choosing, however it did not guarantee that scripts would be completed correctly since there was no opportunity for participants to make queries if they were unsure how a section should be completed. Online instruments were useful in that anonymity was immediately ensured as each student was automatically allocated a participant ID (students would receive the same participant ID when completing online questionnaires) that in turn was associated with their response. The researcher would only have known the participant ID and would not have been able to trace back or identify individual students. At any one time the number of students who would be engaged in some element of research (data collection or intervention) ranged from between 60 to 130, however the availability of computing suites capable of accommodating that number of students simultaneously was limited. Also in completing the online version of the questionnaire it was assumed that all participants would have had an active email address and login, which may not have been true if the students were still in their first few weeks of their course. As a result of this it was decided to proceed with paper-based questionnaires even though it resulted in more time being required to collate the data and manually create participant-script keys to ensure anonymity.

Administration of the instruments - During the administration of the questionnaire many of the students, especially those from non-mathematics courses, were inclined to seek assistance from fellow participants when completing the questionnaire. This was most notable when completing the mathematics diagnostic element of the questionnaire. As Studies 2 and 3 were to be conducted within lecture theatres, it allowed for the conditions under which the instruments were administered to be controlled i.e. spacing of students in rows and forcing all students to face forwards. Students allocated to different conditions who were present in the same lecture could be allocated to specific rows. The presence of the regular lecturer allowed more control over talking and collaboration between participants and reduced the effects of contamination in the main studies.

Duration of Studies 2 and 3 – Study 2 was designed to take place over one year while Study 3 was designed to run for one academic term. When Study 2 was originally designed and implemented, data was collected at three points during the academic year starting during induction week with the second and third sets of data being collected at the start of term 2 and the end of term 3. Originally it was decided not to administer the intervention too early in the year as the students would not necessarily have been expected to use a significant amount of mathematics at the start of the year nor would they be familiar with the mathematical support provision that would be on offer from the university. During the course of the year the mathematical demands placed on the students would increase (ascertained through discussion with heads of department and course leaders of the students who had participated in Study 2). As a result it was expected that running the study over a longer period of time would facilitate habit formation (due to more opportunities to act out and repeat the behaviours outlined in the implementation intentions) by students who had created implementation intentions. Furthermore, a longer study was felt necessary as the type of goal directed behaviours were aimed at carrying out extra mathematical study. For students who do not require much support, a shorter length study may not provide enough opportunities for them to carry out goal directed behaviours in response to an external stimulus. Study 3 was carried out over one academic term due to several issues that were identified from the analysis of the data from Study 2. The major issue was that of student attrition during the course of Study 2, during each subsequent stage of data collection a sizeable proportion of students either dropped out (due to a lack of interest in the study, being absent or withdrawing from their course of study) or attending latter parts of the study without attending the initial data collection stages of the study. As a result there was only a small number of students where complete data was available. A discussion with course leaders and lecturers regarding this matter yielded a possible solution to this problem. By shortening the duration of Study 3 to one term and only collecting data twice, it was envisioned that there would be greater participation among students and also not suffer the high levels of attrition that were observed in Study 2.

This chapter has described the instruments that were used to collect data from participants in the Pilot study and intervention studies (Studies 2 and 3). Importantly it has also described the development and improvement of the instruments as a result of the Piloting process. It has also been indicated through the trialling of recruitment strategies that the best recruitment procedures involve integration of the recruitment with individual departments. The following chapters describe the intervention studies in more detail together with a discussion of the results of each study.

CHAPTER 5 EXPLORING THE RELATIONSHIPS BETWEEN PERSONALITY, MATHEMATICAL ABILITY AND STUDENTS' DEGREE COURSE (CONCURRENT DATA)

Study 2 was an intervention study which was carried out during the whole of the 2008/ 2009 academic year. The primary purpose of this study was to evaluate the effectiveness of implementation intentions as a method of behaviour change with students from non-mathematics backgrounds when the desired behaviour change goal was improvement in the study behaviours of the students. This study also allowed an exploration of how mathematical ability may be related to personality and course of study and furthermore how these variables are related to the effectiveness of implementation intentions (e.g. Webb et al. 2007). This chapter will focus on the analysis of the substantial amount of concurrent data relating to mathematical ability and personality over a range of different student groups. The analysis of the data which relate to the evaluation of the intervention study itself will be presented in Chapter 6.

5.1 RATIONALE

As noted in Chapter 1, research by Mulhern and Wylie (2004) suggested that the mathematical abilities of psychology students have declined over the past decade and a decline in students' mathematical ability has also been highlighted in other subject areas (Kounine et al. 2008, Williamson, Hirst, Bishop and Croft 2003). As a result there is an observed mismatch in the mathematical abilities of abilities of undergraduate students and the expectations of universities (Hawkes and Savage 2000). Past literature has suggested that there is a relationship between achievement and personality (e.g. Fruyt and Mervielde 1998, Komarraju et al. 2009). Research by Allik and Realo (1997) suggested that personality may not have a direct influence on achievement, although it may explain differences in study behaviours between low and high achievers (see Section 3.1). It has been shown that there is a weak negative correlation between psychoticism and conscientiousness (e.g. Lodhi, Deo and Belhekar 2002). However, the size of the correlation suggests that high levels of psychoticism do not necessarily mean an individual is not very organised or agreeable (Allik and Realo 1997). The definition of psychoticism (Eysenck and Eysenck 1991) suggests that low scorers are more likely to work collaboratively with peers rather than work individually.

Mathematics Support Centres offer opportunities for both individual work and group work. The Mathematics Support Centre at Coventry University has put an emphasis on promoting group study. Many students have also used the Mathematics Support Centre as a quiet place for individual study. Feedback from staff working in the Mathematics Support Centre suggests that many students use the learning space for collaborative learning. Research has found positive correlations between extraversion and various types of study-related behaviours such as preferred noise levels and opportunities to socialise (Campbell and Hawley 1982). Those correlations also suggest that extroverts seek out external stimulation through their learning environments (e.g. opportunities to work with others). Mathematics Support Centres would seem a preferred study location for these individuals due to their layouts, which tend to facilitate collaborative learning. Working in groups through collaborative learning has been suggested to be more productive than working alone (e.g. Vygotsky 1978, Lave and Wenger 1991, Wenger 1998). Studies have suggested that collaborative learning can improve the learning process. A meta-analysis by Webb (1991) examined 17 studies that looked at the effectiveness of students working in five different types of groups, wide ability ranges, narrow ability ranges, high, medium and low ability ranges. Their results suggest that when in a wide ability range group the high and low achieving students adopted the roles of teacher and student while the medium ability students did not engage in the group very much. In a group with a more narrow range of abilities, all of the students seemed to be more engaged, particularly the medium ability students. Within the high, medium and low ability groups it was found that students in the high ability groups tended to perform worse as they all assumed they were right and were less engaged in collaborative learning. Those in low ability groups were not able to exhibit improved learning as they lacked confidence and tended not to be able to provide correct instruction to their peers. Those in the medium ability groups did show improvement when working in a group. This suggests that high achievers may have a preference for working individually if they felt they gained little from other members of the group. A study by Tudge (1992) suggested that it was important for a teacher to engage with students in group based activities such that good strategies are encouraged from students particularly the low ability students. Tudge (1992) also found that in the absence of teacher intervention and feedback within group working situations, students could have diminished performance.

Webb (1993) found that students working in groups of 3 or 4 achieved higher scores on a computational mathematics test than students who had been learning individually. The study also found that those students who had been actively engaged in the group work achieved higher scores than those who had been passive members of the group. A study by Saner, McCaffrey, Stecher, Klein and Bell (1994) looked at students in grades 5 and 8 who had completed 3 science tasks. The first and third were completed individually while the second was carried out in pairs. The results of the study suggested that for high ability students the effect of group work was minimal at best and that scores on the third task could be predicted from scores on the first task as both scores were similar. They also found that for weaker students scores on the third task were greater than that those in the first task suggesting they had benefitted more from the group task. Within higher education, Solomon, Croft and Lawson (2010) looked at the preferred study habits of students. They conducted a number of focus groups with 21 participants who used Mathematics Support Centres, in addition to 38 participants who were asked to complete questionnaires that focused on their learning experiences (school and university) and attitudes towards the learning of mathematics. They found that students preferred to work collaboratively rather than individually. Participants also felt that their learning of mathematics was greatly improved through collaborative learning rather than individual learning. It was found that students also felt that the spaces provided by the university for group study were essential for improved learning experiences.

However, what is unclear from the literature is whether the observed relationships between personality and achievement are true generally or restricted to specific curricular areas i.e. numeracy. Research by Premuzic, Furnham and Lewis (2007) looked at the personality and study preferences of 110 male and 111 female British medical students. All participants completed three self-report questionnaires that were used to measure personality (extraversion, neuroticism, openness, conscientiousness and agreeableness using the Revised NEO Personality Inventory), approaches to learning and learning preferences (e.g. classes, group study, lectures). The results suggest relationships between the teaching preferences of students (i.e. Group discussions, small groups, Laboratory classes, Clinical teaching, Independent study and Lectures) and their personality. Those who preferred independent study scored lower on the extraversion scale. Participants who scored lower on the neuroticism scale and high on the openness scale were found to prefer small group teaching, laboratory classes, clinical teaching and also group discussions.

Given that various types of courses at university have biases (or perceived biases) towards different types of teaching (e.g. mathematics – lectures or Music – practical), it seems sensible to suggest that potential students could partially base their degree course choice and career choice based on their preferences (influenced by their personality). Similarly, personality measures such as the Myers-Briggs MBTI (Briggs, McCaulley, Quenk and Hammer 1998) have been used and developed to aid individuals in assessing the types of degrees / careers and jobs that they would be most suitable for. A study by Garcia-Sedeño, Navarro, and Menacho (2009) looked into how personality traits may or may not be a predictor of future career choice. The study looked at 753 (371 male, 363 female) students aged between 17 and 23 who all competed Cattell's Sixteen Personality Factor-5 Questionnaire (16PF-5 Questionnaire) and the Kuder-C Professional Tendencies Questionnaire. Cluster analysis of the Kuder-C Professional Tendencies Questionnaire data suggested that participants fell into one of two groups. Those preferring to study technology related careers and those with a preference for the social sciences. Examination of the Cattell's Sixteen Personality Factor-5 Questionnaire suggested that the differences between vocational preferences could be explained by the students' personality data. From the literature it is unclear whether there are significant differences between students from different courses with regards to personality. If personality does influence degree choice then this should be observable in the scores on the personality scales measured using the EPQ instrument. Furthermore, the literature suggests that personality has an influence on achievement and as such the differences in personality could manifest as observable differences in mathematical ability.

This study therefore aimed to explore the relationship between mathematics diagnostics scores and personality measures amongst undergraduate students on different non-mathematical courses at Coventry University. Secondly, the study also aimed to look at the difference in personality and mathematical ability between students from different courses of study. The relationships between personality and mathematical ability were examined using concurrent data obtained during the first term of the academic year.

Due to the literature suggesting the relationship between intelligence and personality and also the focus of the research on the usage of Mathematics Support Centres, it was predicted that there would be a negative correlation between scores on the mathematics diagnostic test and scores on the psychoticism scale as those scoring higher on this scale are more likely to work alone (the literature suggests that the most effective learning occurs through collaboration). It was also predicted that there would be differences in mathematical ability and personality between students enrolled on different courses based on literature that suggests that students' course and career choices are influenced by personality.

5.2 METHOD

5.2.1 DESIGN

The year-long intervention study that the data in this chapter were drawn from was of an experimental mixed design. Between participant variables were the course being studied (5 levels) and the condition (2 levels, treatment or control). The personality, mathematics diagnostics, pre-intervention study habits and post-intervention study habits variables were the within participant factors.

As part of the experiment, data were collected at three time points during the academic year. The first (pre-intervention) occurred during the first half of the first academic term. The second (intervention) occurred during the first half of the second term, while the third (post intervention) occurred during the end of the second term. There was a gap of approximately 8 to 12 weeks between the first and second data collection points; while the separation of the third and second data gathering times were around 6 to 8 weeks. Participants sat in rows within the workshops and lecture theatres; and were allocated (within each subject area) to either the control or treatment conditions at the intervention stage of the experiment. Allocation was based on rows (all participants in a given row were placed in the same condition) rather than individuals being randomly allocated to either the control or treatment conditions. An allocation by row was done to avoid potential contamination between adjacent participants from differing conditions. Those in the control group were given a dummy treatment, which for this study was an activity that asked students to describe their feelings and perceptions of infinity (see Appendix 2.9).

However, the focus of this chapter is on the concurrent data gathered during the first half of the first academic term. This chapter will describe and analyse the concurrent data obtained during the early part of the academic year. The rationale and analysis of the intervention itself (longitudinal data) is described in Chapter 6. The design of this initial part of study 2 in this chapter is therefore between groups, with course being studied as the independent variable and performance on the EPQ-R subscales and the mathematics diagnostic assessment as the dependent variables. The study also looked at relationships between personality and mathematical attainment overall and within each of the participant groups.

5.2.3 Participants

In light of the poor response rate obtained using the recruitment strategies used in the pilot study (see Section 4.3), the strategy that was used for data collection in this study was to work with the departments and lecturers of the potential participants to integrate the data collection into their lectures and workshops where possible for the coming year. If this was not possible then it was intended that the research itself could be advertised with the co-operation of the lecturer. The result was the ability to approach and potentially recruit all of the students enrolled on the courses and increase the number of those who chose to volunteer to participate.

Data were gathered from undergraduate students at Coventry University. Usage data from the 'Mathematics Support Centre' (MSC) at Coventry University suggested that students from mathematics and engineering-based courses were the primary users of the MSC (see Table 2.1 of Section 1.2.3). However, students from other courses, particularly those with lower amounts of mathematical content, were not big users of the services. Interviews with teaching staff regarding the mathematical ability of students and that required to pass the course suggests that the reason these students do not make use of the services is not because there is no need to; many students were seen to be struggling with mathematics across many disciplines at the university. A report has highlighted how students are struggling with the mathematics on a diverse range of courses at university level (Norris 2012). The report by Norris suggests that many universities are reducing the mathematical content or placing a reduced emphasis on the quantitative elements of university courses due to the inability of students to cope (Norris 2012: 11). As students from mathematical disciplines were making use of the support, it was decided to focus the research on the students who were under-represented when accessing mathematical support. In selecting the courses it was decided to select students who were enrolled on programmes of study where students were not required to have an A-level mathematics or equivalent qualification. The five courses from which participants could be drawn were, Nursing, Business Management, Business

Foundation Year, Psychology and Sports Science. From discussions with staff who worked with students on these courses, and staff from the Mathematics Support Centre, it was apparent that they felt there was a sizeable proportion of students who were unable to cope with the mathematics on their chosen courses and out of these students only a few were making use of the support mechanisms the university had on offer (this again was reflected in the usage data shown in Section 1.2.3). Coventry University has an intake of students that is diverse in terms of age, mathematical background, gender, mode of study and fee status (referring to being either a home or international student).

Participants in this study formed a self-selecting, opportunistic sample. A total of 393 students from the selected courses volunteered to participate in the first term data collection. Of the 393 who volunteered, concurrent data relating to mathematics diagnostic scores and personality was available for 288 participants, data from 105 participants did not provide complete personality data or mathematics diagnostic data as a result of not participating in all parts of the study; Table 5.1 shows the composition of the participants where personality and mathematics diagnostic data were available.

Table 5.1: Age, gender and university course of those involved in the study*

Course	Male	Female	Undeclared	Mean Age	Median Age
Business Foundation year	41	34		19.96	19.00
(SD)				(3.87)	
Business Management	20	41		20.77	19.00
(SD)				(4.32)	
Adult Nursing	4	46	1	25.10	23.00
(SD)				(6.50)	
Psychology	4	49	1	21.13	19.00
(SD)				(5.55)	
Sports	20	27		19.38	19.00
(SD)				(2.34)	

*Mean and Median Age based on data where gender and age were available. In the above

5.2.4 Materials

Data were gathered to measure the relationship of a number of personality measures (e.g. psychoticism and extraversion) with mathematical ability and the effectiveness of implementation intentions was also explored. To explore the above several instruments were used to gather data on demographics, mathematical ability, social desirability, personality and mathematical study habits.

Demographic data e.g. age, course, mode of study, mathematical background were collected using an instrument developed during piloting phase (see Appendix 2.12 for Version B); doing so allowed the analysis to take into account variations in student backgrounds. To assess Mathematical abilities a Mathematics diagnostic questionnaire developed during piloting phase was used to explore the participants' ability to answer typical GCSE level mathematics questions (see Appendix 2.3 and 2.4 for Versions B and C). For personality measurement, the Eysenck Personality Questionnaire (EPQ-R) was used to measure the personality traits of psychoticism, extraversion and neuroticism. The study habits of participants including their use of university provided support services pre intervention was measured using an instrument developed during the piloting phase, (see Appendix 2.6 for Version B). Social desirability was shown to be a possible source of bias in the responses from participants on self report instruments, to ascertain the effect this could have had on the responses from this study the Marlowe Crowne Social Desirability questionnaire was also administered as part of the procedure (see Appendix 2.8). Further details of the instruments can be found in Chapter 4.

5.2.5 Procedure

Before any student was able to participate it was important that all of the students were completely aware of what participation in the research entailed, its main aims and how to withdraw. This was accomplished by providing an information and consent document to the participants during the pre-intervention stage (see appendix 2.15). All participants were also debriefed and encouraged to give feedback on their experiences of participating in the research. All students who wished to participate were able to express their willingness to do so by signing the informed consent document. Through a discussion with the lecturers and course leaders suitable timeslots were identified where the data collection would take place. The process took a maximum of 50 minutes and either replaced a timetabled lecture or was appended to an existing lecture.

Outline of data collection

1. Before proceeding, a brief overview of the research was given to the participants of no more than 5 to 8 minutes (the researcher handed out consent paperwork and questionnaires if this had not already been done)
2. Participants were asked to complete consent form (5 minutes)
3. Participants were asked to complete the five questionnaires shown in table 3 (25 to 30 minutes)
4. Participants were asked to check that they have recorded their student number on their completed questionnaires (3 minutes)
5. Collection of questionnaires and other documentation.

Student numbers were only recorded so that pre and post intervention data could be linked. After all of the completed questionnaires have been collected, each script was allocated a random 3 digit numerical participant ID. A key was then constructed linking the student numbers to the participant ID. Any subsequent testing would again require students to provide their student number that would then be replaced with the participant ID. To address ethical concerns regarding anonymity for students, once a participant ID had been created for a student, any reference to the student number on scripts were erased and replaced with the participant ID. All questionnaires were destroyed once the data had been recorded, the key was retained and stored securely until the intervention study was complete. Once the participants had been given adequate time to withdraw from the study the key was also destroyed.

5.3 RESULTS

5.3.1 NORMALITY AND STATISTICAL TESTS

Kolmogorov-Smirnov and Shapiro-Wilk tests of normality were performed on the personality and mathematics diagnostic variables. In all cases both the Kolmogorov-Smirnov and Shapiro-Wilk tests suggested distributions that were far enough away from being normal to indicate the use of non-parametric methods when performing analysis on the whole group of students.

Tests for normality were also performed within subject groups and were found to suggest that data were not as far from normal as the combined data were (see Appendix 3.2). However, in most cases the data were still significantly far from normal to suggest that it would be unwise to use parametric testing. A number of transformations were used to address the negative and positive skew. The transformations did normalise that data within some sub-groups, but caused other sub groups of data to deviate further from normality. Some data also had leptokurtic and platykurtic distributions and unfortunately transformations could not correct these distributions and did not adequately address the normality issues. Based on the normality tests and transformations, non-parametric methods were used. Furthermore Levene's test for homogeneity of variance was also found to be significant for the psychoticism data between the course groups.

5.3.2 Summary Statistics

As shown in Table 5.2, there appear to be small differences in personality and mathematical ability across the five subject groups. Students studying Business courses appear to score lowest on the mathematics diagnostic test and highest on the psychoticism scale compared to students from other courses. There also appear to be large differences between the groups on the neuroticism scores with Business Foundation Year Students scoring the lowest while Nursing and Psychology students scoring the highest.

Table 5.2: Mean and median scores on the mathematics diagnostics and EPQ-R instruments across different subject groups at Coventry University.

Course	*N**	*Maths diagnostic*	*Psy.*	*Ext.*	*Neu.*	*Lie*	*Add.*	*Cri.*
BFY	75/ 73	4.61, 5	8.86, 8	15.86, 17	11.61, 11	9.86, 10	10.92, 11	13.00,13
(S.D)		(1.94)	(4.20)	(4.36)	(5.33)	(4.46)	(4.84)	(5.01)
BM	61/ 61	4.51, 4	8.54, 8	17.38, 18	12.28, 13	8.98, 9	11.79, 12	14.25, 14
(S.D)		(2.20)	(3.66)	(3.49)	(4.63)	(3.91)	(3.80)	(4.61)
AN	51/ 51	5.80, 6	5.82, 5	16.18, 17	12.85, 15	10.71, 11	10.27, 9	12.39, 13
(S.D)		(1.74)	(3.05)	(4.17)	(6.06)	(4.22)	(5.10)	(5.12)
PSYG	54/ 50	5.75, 6	6.52, 6	16.34, 17	14.34, 15	8.58, 8.5	12.14, 12	13.50, 14
(S.D)		(2.25)	(2.65)	(4.63)	(5.12)	(3.79)	(4.60)	(4.87)
SPT	47/ 44	6.17, 6	7.59, 7	17.72, 19	11.68, 12	8.30, 8.5	10.93, 12	12.93, 13
(S.D)		(1.87)	(4.56)	(3.57)	(5.04)	(4.14)	(4.72)	(4.48)
AC	288/ 279	5.27, 5	7.64, 7	16.63, 17	12.48, 12	9.35, 9	11.21, 11	13.24, 14
(S.D)		(2.11)	(3.88)	(4.12)	(5.30)	(4.19)	(4.63)	(4.85)

**the first number represents the total number of participants the second number show how many provided complete data.*

Where N = Maths Diagnostic/EPQ-R, BFY = Business Foundation Year, BM = Business Management, AN = Adult Nursing, PSYG = Psychology, SPT = Sports, AC = All courses, Psy. = psychoticsm, Ext. = extraversion, Neu. = neuroticism, Add. = addiction, Cri = criminality. For all mathematics diagnostics and EPQ-R scores the data were in the following format - Mean, median (SD)

Data in Table 5.3 shows the median personality and study habits scores across the subject groups. Data suggests that students on the Business Foundation Year course and those studying Psychology studied for a greater amount of time than those on other courses. For all subject groups, estimates of their future study behaviours were greater than their actual study habits; aspirations of study were greater still.

Table 5.3: The median scores for personality and mathematics diagnostic tests where complete pre intervention data on study habits of students was available.

						Pre–intervention measures of study habits		
Course	*N**	*Maths Diagnostic*	*Psy.*	*Ext.*	*Neu.*	*Actual study time*	*Aspirational time*	*Estimated study time*
BFY	33/32	5	8	15.5	11.5	15	21	16
(S.D)		(1.58)	(3.7)	(5.27)	(5.91)	(13.16)	(20.48)	(17.15)
BM	-	-	-	-	-	-	-	-
(S.D)								
AN	23/23	6	5	16	15	5	7	6
(S.D)		(1.69)	(2.91)	(4.89)	(5.75)	(18.13)	(20.34)	(18.8)
PSYG	10/10	5.5	5.5	14	12	22	27	24
(S.D)		(2.94)	(2.33)	(5.25)	(5.25)	(30.14)	(42.64)	(77.5)
SPT	28/25	6	7	17	13	3	4	3
(S.D)		(1.69)	(5.12)	(3.93)	(4.95)	(11.34)	(28.89)	(12.1)
AC	94/90	5.5	6	16.5	12.5	7.5	12	8
(S.D)								

Where BFY = Business Foundation Year, BM = Business Management, AN = Adult Nursing, PSYG = Psychology, SPT = Sports, AC = All courses, Psy. = psychoticism, Ext. = extraversion, Neu. = neuroticism. For each group of students the number of hours that the student has studied in a typical month and their estimates and aspirations of future study are recorded in the table. For all mathematics diagnostics, EPQ-R scores and study habits, the data were presented in the following format - median (SD).

**the number of participants where complete data was available was reported in the following format A/B, A = number of participants where mathematics and study behaviour data was available. B = number of participants where complete mathematics, personality and pre-intervention data on study habits was available.*

5.3.3 Differences between the groups

A Kruskal-Wallis test was conducted to assess whether the personality traits (psychoticism, extraversion, neuroticism, lie, addiction and criminality) and mathematics diagnostics scores differed significantly across subject groups. A significant difference between the groups was found on the mathematics diagnostic test, $H(5) = 33.088$, $p < 0.01$ and psychoticism scores, $H(5) = 33.568$, $p < 0.01$. Post-hoc testing consisted of ten Mann-Whitney U tests to compare all the possible parings of subject groups. As ten tests were performed, a Bonferroni correction was used such that significant effects occurred when $p < 0.005$ rather than $p < 0.05$. The results of the Mann-Whitney testing are summarized in Tables 5.4 and 5.5 (below).

Table 5.4: Results from the Mann-Whitney tests that show the estimated effect size r for each comparison of maths diagnostic score between students from different courses.

Course	N	Mathematics Diagnostic (Median)	1 - BFY	2- BM	3- AN	4- PSYG	5- SPT
1	75	5	-	-0.035	-0.308*	-0.263*	-0.362*
2	61	4	-	-	-0.329*	-0.284*	-0.388*
3	51	6	-	-	-	-0.018	-0.091
4	54	6	-	-	-	-	-0.096
5	47	6	-	-	-	-	-

*significant at $p < 0.005$ level

Where BFY = Business Foundation Year, BM = Business Management, AN = Adult Nursing, PSYG =Psychology, SPT = Sports

The results of the tests summarised in Table 5.4 suggest that the students from Adult Nursing, Psychology and Sports scored significantly higher than students from both Business Management and Business Foundation year courses on the mathematics diagnostic test, $U = 6707.5$, $z = 5.610$, $p < 0.001$, $r = -0.327$. There was no significant difference in mathematics diagnostic scores between Business Foundation Year and

Business Management students (U = 2195.0, z = -0.410, p = 0.682, r = -0.035). There was also no significant difference between Adult Nursing and both Psychology (U = 1349, z = -0.182, p = 0.856, r = -0.018) and Sports (U = 1074, z = -0.897, p = 0.370, r = -0.091) students. Similarly there was no difference between Psychology and Sports students' scores (U = 1129.5, z = -0.961, p = 0.337, r = -0.096). Furthermore, the data suggest that the students from Adult Nursing, Psychology and Sports scored significantly higher than those from both Business Foundation year and Business management.

Table 5.5: Results from the Mann-Whitney tests that show the estimated effect size for each comparison of psychoticism score between students from different courses.

Course	N	Psychoticism (Median)	1- BFY	2- BM	3- AN	4- PSYG	5- SPT
1	73	8	-	-0.002	-0.363*	-0.268*	-0.182
2	61	8	-	-	-0.394*	-0.297*	-0.189
3	51	5	-	-	-	-0.138	-0.178
4	50	6	-	-	-	-	-0.035
5	44	7	-	-	-	-	-

*significant at $p < 0.005$ level

Where BFY = Business Foundation Year, BM = Business Management, AN = Adult Nursing, PSYG = Psychology, SPT = Sports

The results of the tests summarised in Table 5.5 suggest that on the psychoticism scale, Business Management and Business Foundation year students scored significantly higher than both Psychology and Adult Nursing students, *U* = 4256.5, *z* = -5.439, $p < 0.001$, *r* = -0.350. There was also no significant difference in psychoticism scores between Business Foundation Year and Business Management students (*U* = 2222.5, *z* = -0.18, *p* = 0.987, *r* = -0.002), there was also no significant difference in the scores of Sports Science students when compared to Business Foundation Year students (*U* = 1010.5, *z* = -1.901, *p* = 0.058, *r* = -0.182) and Business Management students (*U* = 1045.5, *z* = -1.936, *p* =0.053 *r* =-0.189). Similarly it was found that there was no significant difference in the scores of Sports Science students when compared to Adult Nursing (*U* = 891.5, *z* = -1.731, *p* = 0.083, *r* = -0.178) and Psychology (*U* = 1054, *z* = -0.351, *p* = 0.726, *r* = -0.035), and there was also no statistically significant difference between Psychology and Adult Nursing scores (*U* = 1071, *z* = -1.395, *p* = 0.163, *r* = -0.138).

5.3.4 Correlations between personality and mathematics diagnostic scores

To test the strength of the relationships between mathematics diagnostics performance with personality traits measured using the EPQ-R instrument, Kendall’s tau (two-tailed tests) correlation coefficients were examined. The results can be seen in Table 5.6 (below).

Table 5.6: Kendall's tau coefficients showing the correlations between predictor variables and mathematics diagnostic scores

	N	*Psy.*	*Ext.*	*Neu.*	*Lie.*	*Add.*	*Cri.*
Business Foundation Year	73	0.002	0.015	-0.159	0.159	-0.022	-0.11
Business Management	61	0.226*	0.203*	-0.011	-0.242*	0.082	0.074
Adult Nursing	51	-0.103	-0.193	-0.169	0.014	-0.094	-0.203
Psychology	50	-0.306**	0.099	-0.128	-0.025	-0.141	-0.131
Sports	44	-0.095	-0.038	-0.119	0.078	-0.159	-0.203
All Courses	279	-0.088*	0.034	-0.030	-0.013	-0.041	-0.067

*significant at the $p < 0.05$ level, ** significant at the $p < 0.01$ level

Where Psy. = psychoticism, Ext. = extraversion, Neu. = neuroticism, Add. = addiction, Cri = criminality

From Table 5.6 it can be seen that when looking at data from all of the participants there is a significant but weak correlation between psychoticism and diagnostic test performance, $r = -0.088$, $p < 0.05$. According to Cohen (1992), a result of $r = -0.088$ would be classed as a small effect and unobservable without careful examination of the data through statistical tests. Due to the very small r it is suggested here that this correlation although statistically significant may be misleading and of little predictive use). However, there was no significant correlation between extraversion and diagnostic test scores. The same result was not found within individual subject groups, a summary of which is given in Table 5.7 below.

Table 5.7: Kendall's tau correlations between personality and mathematics diagnostic scores across subject groups

Course	*psychoticism with mathematics diagnostic scores (Kendall's tau)*	*extraversion with mathematics diagnostic scores (Kendall's tau)*
All students	Yes (-0.088)*	No
Business Foundation Year	No	No
Business Management	Yes (0.226)*	Yes (0.203)*
Adult Nursing	No	No
Psychology	Yes (-0.306)**	No
Sports	No	No

*significant at the $p < 0.05$ level, **significant at the $p < 0.01$ level

From Table 5.7 there seems to be a significant correlation between mathematical diagnostic performance and psychoticism for students from Business Management ($r = 0.226$, $p < 0.05$) and Psychology ($r = -0.306$, $p < 0.01$) but not for others. With regards to correlations between mathematics diagnostics performance and extraversion only Business Management students showed a significant result, $r = 0.203$, $p < 0.05$. However, a comparison between the correlation results and the initial idea that there is some connection between the psychoticism and mathematics diagnostics scores only seems to hold true within some student groups (Business Management and Psychology).

5.3.5 *An analysis of the relationships between mathematical ability and personality with study behaviours on entry*

Kendall's tau correlation coefficients were examined to test the relationships of mathematics ability and personality with study behaviour and personality. The results of the analysis can be seen in Table 5.8 (below).

Table 5.8: Kendall's tau correlation coefficients showing the correlations between predictor variables and the data on study habits

Course	*Predictor*	*N*	*Actual Study time*	*Aspirational Study time*	*Estimated Study time*
All Students	*Mathematics Diagnostic Test*	*94*	*-0.062*	*-0.028*	*0.009*
	Psychoticism	*90*	*-0.016*	*-0.065*	*-0.030*
	Extraversion	*90*	*0.000*	*-0.088*	*-0.046*
	Neuroticism	*90*	*0.090*	*0.015*	*0.053*
Business Foundation year	*Mathematics Diagnostic Test*	*33*	*-0.273**	*0.247*	*0.259*
	Psychoticism	*32*	*-0.049*	*-0.085*	*-0.026*
	Extraversion	*32*	*-0.049*	*-0.128*	*-0.066*
	Neuroticism	*32*	*-0.286**	*0.286**	*0.265**
Adult Nursing	*Mathematics Diagnostic Test*	*23*	*-0.178*	*-0.220*	*-0.138*
	Psychoticism	*23*	*-0.054*	*-0.075*	*-0.085*
	Extraversion	*23*	*0.240*	*0.150*	*0.194*
	Neuroticism	*23*	*-0.120*	*-0.195*	*-0.146*
Psychology	*Mathematics Diagnostic Test*	*10*	*0.068*	*0.092*	*0.138*
	Psychoticism	*10*	*-0.068*	*-0.092*	*-0.046*

	Extraversion	*10*	*-0.114*	*-0.322*	*-0.184*
	Neuroticism	*10*	*0.230*	*-0.023*	*0.070*
Sports	*Mathematics Diagnostic Test*	*28*	*0.000*	*0.093*	*0.085*
	Psychoticism	*25*	*-0.183*	*-0.223*	*-0.191*
	Extraversion	*25*	*0.069*	*0.063*	*0.048*
	Neuroticism	*25*	*-0.103*	*-0.058*	*0.062*

*significant at the $p < 0.05$ level, ** significant at the $p < 0.01$ level

The data in Table 5.8 do not seem to suggest any association or relationship between reported study habits and the predictor variables (mathematics diagnostics and EPQ-R scores). However, the data from individual course groups suggest that there were statistically significant correlations of neuroticism with Actual ($r = 0.286$, $p < 0.05$), Aspirational ($r = 0.286$, $p < 0.05$) and Estimated ($r = 0.265$, $p < 0.05$) self reported measures of study behaviour for those studying the Business Foundation Year course. Although there was no overall statistically significant correlations between mathematical ability and actual amount of time spent engaged with study, those in the Business Foundation Year group exhibited a statistically significant negative correlation between mathematical ability and study habits ($r = -0.273$, $p < 0.05$), suggesting that those who were not as good at mathematics were engaged in higher levels of study. It is unclear why the relationship was only observed in the

Business Foundation Year group.

5.4 DISCUSSION

Analysis of the concurrent data showed that there was a significant difference between the student groups on both the psychoticism and mathematics diagnostic scales. It was also found that neither mathematical diagnostic scores or personality scores were correlated with the amount of time spent engaged with mathematical study except in the case of those studying on the Business Foundation Year course. It was also found that groups of students who scored highly on the mathematics diagnostic test generally scored lower on the psychoticism scale than those groups who scored lower on the mathematics diagnostic test. However, the negative correlation between mathematics diagnostic score and psychoticism score was not found to be consistent across the range of courses involved in the study. A significant positive correlation was found for Business Management students and a significant negative correlation was found amongst the Psychology students only. This seems to go against the literature, which suggests that this correlation should have been observed to some degree within all groups that were assessed. A study by Manzurul, Rabman and Mahmud (1986) found that academic achievement correlated negatively with the EPQ-R measure of psychoticism. Eysenck and Eysenck (1976) also argued that educational achievement and psychoticism should be negatively correlated with each other. A study by Chamorro-Premuzic and Furnham (2003) found that the academic performance of 75 British university students was associated with the EPQ-R personality measures of psychoticism, extraversion and neuroticism. Of these three variables they observed a negative association between psychoticism and academic performance. The weak negative correlation between the psychoticism trait and conscientiousness also suggests that high scorers on the psychoticism scale may have been less likely to follow through with their strategies for study and adhere to any study schedule they may have created, consequently they were less able to follow through with their strategies for study and adhere to any study schedule they may have created, consequently they are less likely to be able to engage with independent study and comply with deadlines. High scorers on psychoticism were considered to be less able to fit in and work with others (Section 4.4.3). The results of the inability to adhere with study schedules are likely to manifest as observed reductions in academic performance. The results of the tests carried out to examine the influencing factors of study habits using the measures of mathematical ability and personality need to be treated with caution. It is likely that the amount of mathematics that the different groups were required to engage with was significantly different at the time the study behaviours questionnaire was administered. Unlike the mathematics and personality questionnaires, the study behaviour data were collected later on during the academic year. It is also possible that the students improved their mathematical skills between taking the mathematics diagnostic test and the time when pre-intervention data on study habits was collected. The negative correlations between maths diagnostics scores and actual study observed in the Business Foundation Year group was explained by the students on that course being required to undertake a numeracy and mathematics diagnostic test as part of their course of study. However, given that data on the mathematical demands of students leading up to the pre-intervention data on study habits collection instrument is not available, it does not appear possible to meaningfully interrogate the data further without making assumptions that could be inherently incorrect or flawed.

Before discussing the level of psychoticism between groups, it is important to revisit the notion of psychoticism as measured using the EPQ-R. Psychoticism as described by Eysenck and Eysenck (1991: 6) suggests that a high scorer may exhibit antisocial tendencies, including an inability to form meaningful relationships with those around the individual. However, they also state that the instrument is designed to measure the tendency of the general population to exhibit psychotic tendencies. As such, it is only applicable in cases where the behaviours are non-pathological (as is assumed of the participants in the reported study). Within this study psychoticism does not primarily refer to the anti-social tendencies of the participants as suggested by Eysenck and Eysenck (1991) but rather to academic and study-related dispositions and tendencies. To clarify this, psychoticism can be thought of as being a combination of scales i.e. conscientiousness and agreeableness and openness (Matthews et al. 2003). A study conducted by Lodhi, Deo and Belhekar (2002) involving 300 undergraduate students at a university in India explored the relationship between the big five factors as measured by NEO-FFI and the three factors of EPQ-R; it was found that there were significant correlations between psychoticism and both agreeableness (r = -0.42, $p < 0.001$) and conscientiousness (r = -0.33, $p < 0.001$). Significant correlations were also found by Lodhi, Deo and Belhekar between lie and both agreeableness (r = 0.51, $p < 0.001$) and conscientiousness (r = 0.46, $p < 0.001$). Their study also found very small but significant correlations between psychoticism and openness.

The literature described earlier in this chapter suggests that conscientiousness is positively correlated with academic achievement suggesting that high scorers on the conscientiousness scale are more likely to score higher in intelligence tests than those who score lower on the conscientious scale. In light of this and the contributions of Matthews et al. (2003) and Lodhi, Deo and Belhekar (2002), it would be expected that participants who scored lower on the psychoticism scale would score higher on a test of ability (such as the mathematical diagnostic test as used in this study). However, as reported earlier in Section 5.3.4, this correlation was only found to be true within some groups of students (see Table 5.7). Those groups scoring lower on the psychoticism scale scored higher on the mathematics diagnostic test than higher scoring groups, which to some extent would support the literature on the relationship between psychoticism and academic achievement.

However the literature suggests that the relationship between extraversion and achievement is harder to identify. Allik and Realo (1997) for example found no significant correlation between extraversion and intelligence tests, only finding significant correlations between extraversion and language related tasks. Furthermore, research by Martin et al (2006) (using scales for ambition and sociability that could be considered proxies for extraversion) suggests that extraversion is correlated with achievement. From the analysis of the data from this study, the evidence would suggest that there is no significant correlation between extraversion and mathematics achievement.

These results can be used to provide information about the types of learners who were involved in the study, in particular those who scored lower on the mathematics diagnostic test and higher on the psychoticism scale. As was discussed earlier, the literature suggests that conscientiousness is negatively correlated with psychoticism. It is suggested that those who tended to score higher on the psychoticism scale were more inclined to work individually, less able to work in groups and find it harder to follow through with personal study intentions and schedules. Learning through group work, collaboration and the formation of communities of learning have been shown to be important in the learning process e.g. Social Constructivism (Vygotsky 1978) and Communities of Practice (Lave and Wenger 1991, Wenger 1998). Furthermore, the ability to adhere with personal study intentions and schedules is important in allowing students to undertake effective private study, not just of mathematics but with their whole course of study.

It is beyond the scope of this thesis to ascertain if either psychoticism or extraversion can be used as predictors for mathematical ability either within or across disciplines. However, the data do suggest that students from different disciplines would appear to have significantly different psychoticism scores and mathematics scores, with those groups who scored higher on the psychoticism scale tending to have lower mathematics scores (e.g. Business students). Importantly, it should be noted that these conclusions are based on the assumption that a mathematical test is an acceptable proxy for mathematical aptitude. As this cannot be taken as fact, the maths diagnostic test is only taken as a proxy that indicates how well a student would perform when taking a mathematical test as part of their course and to some small extent their knowledge. However undertaking tests and assessment is an important part of an individual's university study and as such the diagnostic test can still be thought of as a useful tool for predicting performance under similar conditions. If the results from this study were to be generalised to students from other disciplines then there are implications for how students from different subjects are assisted in not only developing their mathematical abilities and examination technique, but also on the effectiveness and value that the assistance would provide. An additional instrument to measure perceived ability could be used in place of the mathematics diagnostic test to measure attitudes and beliefs relating to the participants' relationship with mathematics; in particular confidence, comparison with peers and perceived academic needs as this would have been a better indicator of motivation than actual ability.

5.4.1 IMPLICATIONS

The results of this study have several implications for how mathematics-related content is taught to undergraduate students not just within practical workshops but also through supplementary support services offered by the university. Firstly the correlation between psychoticism and mathematical achievements was not consistent between subject groups and suggests that there is a significant difference between the personalities of the groups. Where psychoticism was correlated to mathematical ability it is proposed that increased efforts must be made to ensure those who ordinarily are not inclined to work collaboratively (i.e. those groups who scored higher on psychoticism) are assisted in doing so in a supportive environment where their group working skills are encouraged and developed. From the definition of psychoticism, it would seem sensible to suggest that those students from courses that score significantly higher than most on the psychoticism scale may consequently spend less time addressing self-diagnosed mathematical problems due to increased difficulties in organisation, planning and sticking to personal study goals (again suggested by higher scores on the scale). However, the data from this study (see Table 5.8) does not support this conclusion. Though a negative correlation was observed across all the course groups; all were weak and not statistically significant. It is sensible to conclude that there are other factors that contribute to low attainment including peer influences (constructive and detrimental), personal issues, family commitments. These students may benefit from peer-support strategies, which could help initiate and maintain their personal study behaviours. Secondly the observed difference between groups on psychoticism and mathematics ability, especially the correlation between the two scales, suggests that teaching strategies aimed at taking account of students who are less able to collaborate with others may not be equally effective with students from different disciplines, the importance of being able to collaborate and work with peers was shown to be of importance in the effectiveness of the learning process (Web 1993, Saner et al. 1994, Webb 1991, Lave and Wenger 1991).

Significant correlations between mathematics and psychoticism were observed for the 1st year psychology students, which suggests that for those students with lower levels of psychoticism are more likely to have higher mathematics ability on entry. However, without data on their end of year results it is not possible to conclude whether psychoticism is a measure of mathematical performance or aptitude over the academic year. However, it is worth noting that no correlation was found between psychoticism and mathematical ability for some groups of students and if it is assumed that their ability to plan, organise and follow through with goals has no effect on their academic performance then it could be concluded that such an intervention aimed at improving these skills may have no beneficial effect. No data were gathered to suggest that psychology students were unaware of the mathematical components of their chosen course. However, it was concerning that although all of the participants had in the past achieved a grade C or equivalent in mathematics at GCSE, the scores on the mathematics diagnostic test suggest that many students lacked basic numeracy skills that they should already possess. Research has suggested that personality can differentiate between those with preferences for science careers and those preferring arts and social sciences. Further research is needed to ascertain why there was a significant difference in psychoticism scores between groups in this study. Was this due to certain courses attracting students of certain dispositions, i.e. ability to work in groups, ability to plan, or were there other underlying factors which were not captured using the instruments in this study and could account for the differences between the groups. A future study may use the Cattell's Sixteen Personality Factor-5 Questionnaire as used by Garcia-Sedeño, Navarro, and Menacho (2009) or the Revised NEO Personality Inventory to better examine the personality differences between students studying different courses in the social sciences.

The analysis in this chapter looked at the concurrent data and suggested that for some student groups there seemed to be a correlation between psychoticism scores and mathematical performance on the diagnostic test. However, this was not consistent across the course groups that were being looked at. In the next chapter, the data relating to the study habits of the students is examined. In particular the aim of Chapter 6 was to assess the effectiveness of implementation intentions on changing the mathematical study behaviours of students from non-mathematical backgrounds.

CHAPTER 6 - EXAMINING THE EFFECT OF FORMING IMPLEMENTATION INTENTIONS ON STUDY BEHAVIOURS OVER AN ACADEMIC YEAR

The previous chapter discussed the results of the concurrent data that were collected during the first part of Study 2. However, this study was designed to examine the effectiveness of forming implementation intentions as a method of improving engagement with mathematical study over the course of a single academic year. This chapter therefore considers the data collected from participants over the three assessment points of the intervention study. The results of this study suggest that the creation of implementation intentions could help to improve the time spent engaged with mathematics-related study behaviours, but not student's aspirations or estimates of future study.

6.1 RATIONALE

Provision has been made by many universities to help to facilitate students' mathematical study outside of scheduled classes at both departmental and university-wide level such as the Maths Café (Portsmouth 2008). However, as they are optional activities, students need to engage with these services of their own volition if they are to realise any potential benefits of the support provision. Research has suggested that not all students who need to use these services make use of the services (Symmonds, Lawson and Robinson 2008). Implementation intentions (Gollwitzer 1999) have been suggested as a method to improve goal-related behaviours in a diverse range of primarily health-related behaviours. Meta-analyses (Gollwitzer and Sheeran 2006) suggest that the formation of implementation intentions can facilitate goal-directed behaviours with medium to large effect sizes. Research also suggests that personality may moderate the effectiveness of implementation intentions (Webb, Christian and Armitage 2007). It was therefore argued in Chapters 2 and 3 that implementation intentions could be used as a method to promote increased engagement with mathematical study outside of timetabled lectures. However, there are important differences between the types of goal-directed behaviours studied previously and those of primary interest here. Previous studies are characterised by either complete cessation or complete adherence to a behaviour, such as Casper (2008) and Luszczynska (2006). The type of behaviours of interest within this study may not be as amenable to change as those studied in the past, because complete adherence or abstinence was not the goal. Participants would be required to engage with a level of mathematical study that would be appropriate for their level of ability. A student with a high mathematical ability would not be expected to adhere to a plan that required them to study mathematics 4 hours every day. While a student with a number of areas of development may require regular visits to the Mathematics Support Centre.

This intervention study aimed firstly to ascertain whether implementation intentions could be used to increase the amount of time spent engaged with mathematical study (including Mathematics Support Centre usage). Secondly, it aimed to find out if personality or mathematical ability were factors which could influence the effectiveness of the implementation intentions. It was therefore predicted that participants who constructed implementation intentions (treatment group) would show a significantly greater increase in the amount of time spent engaged with mathematical study relative to a randomised control group. It was also anticipated that the amount of time students' spent engaged with mathematical study (irrespective of condition) would be negatively correlated with scores on the psychoticism scale. Lastly, the effect of the measured mathematical competencies on the effectiveness of the intervention was examined; it was predicted that there would be a significant negative correlation between scores on the test of mathematical ability and the amount of improvement shown in study skills behaviour between pre and post-test.

6.2 METHOD

6.2.1 DESIGN

In the previous chapter (see Section 5.2.1) the design of the study was described as a mixed (pre-test, post test) design. Data were gathered at three time points during the academic year as shown in Table 6.1 (below).

Table 6.1: Time plan for the data gathering and interventions

Stage	Time	Instrument	Treatment or control group
Pre-intervention	September 2008 – November 2008	• Demographic data • Mathematics diagnostic • Social desirability questionnaire • Personality measurement	Both
Intervention	January 2009 – February 2009	• Support service usage	Both
		• Worksheet on implementation intentions	Treatment
		• Worksheet on another task unrelated to the formation of implementation intentions	Control
Post-intervention	March 2009 – April 2009	• Support service usage • Mathematics diagnostic	Both

The first assessment occurred during the beginning of the first term that the students spent on their course. During this 'pre-intervention' phase, baseline data on the students' mathematical abilities at the point of course entry and their personality was assessed (see Chapter 5). The participants' usage of the Maths Support Centre and other study behaviours were not assessed at this early stage of the year, because the students had only just started their courses and were therefore unaware of the maths provision available or whether they were in need of such support. These data were collected instead at the second assessment point, which also included the intervention phase of the study. This occurred during the first half of the second term. The post-intervention assessment of study behaviours and mathematical ability occurred at the end of the second term. There was a gap of approximately 8 to 12 weeks between the first and second data collection points; while the separation of the third and second data gathering times was around 6 to 8 weeks. Participants were allocated (within each subject area) to the control and treatment conditions at the intervention stage of the experiment. Allocation was based on rows (all participants in a given row were placed in the same condition) rather than individuals being randomly allocated to either the control or treatment conditions. Those in the control group were given a dummy treatment (see Section 6.2.4 Materials).

6.2.2 Participants.

A total of 393 students volunteered to participate in the first term data collection (see Chapter 5 and Section 5.2.3). These students were asked to participate in the intervention part of the study that occurred during Term 2. Recruitment of participants followed the same strategy as discussed in the previous Chapter and took into account the lessons learned from the Pilot study (see Section 4.3).

Of the 393 participants who participated in at least one of the three data collection sessions (one in the first term and two in the second term), complete data (where participants had participated in both data collection sessions during the second term) for mathematical study behaviour was available for 61 participants (28 control and 33 treatment combined). Table 6.2 shows the composition of the participants where complete study behaviour data were available. The 61 participants were studying on Business Foundation Year (*N* = 16), Adult Nursing (*N* = 16), Psychology (*N* = 11) and Sports Science (*N* = 18) courses.

Table 6.2: Gender and age data for participants where data on study habits was available.

	Male	Female	Undeclared	Total
N	23	19	19*	61
Age	19.05	22.18	n/a	20.73**
(SD)	(1.13)	(5.09)		(4.08)
Control	13	12	3	28
Treatment	10	7	16	33

*Gender and age data not available for 19 participants

** based on participant data where gender and age data was available

During the second term, participants were allocated to either the control or the treatment conditions. The experiment took the form of a quasi-randomized controlled trial, and as such it was important to ensure that participants had an equal chance of being allocated to conditions without forming biased groups.

Having access to all of the participants in the same lecture theatre seemed like a good method by which to get a high response rate for the data collected at pre-intervention, intervention and post-intervention stages. However, at the intervention stage of data collection this method of data collection reduced the ability to physically separate the control group from the treatment group. In an ideal situation the control group (dummy treatment) would not have been in close proximity to those being given the treatment. This was not possible due to the accessibility constraint of the treatment having to be administered at some point within a lecture session. This problem was dealt with in a similar manner to previous research on implementation intentions. For example a study by Webb et al. (2007) was carried out in lecture theatres and used two alternate forms of a questionnaire; the treatment condition version included instructions for forming implementation intentions while the control version did not.

Similarly in this study all students who participated were given an activity (worksheet) to complete during the intervention. Those who made up the treatment group were given a worksheet which guided them through the formation of an implementation intention, whilst those who made up the control group were given a similar worksheet which comprised of an activity which would not result in the formation of an implementation intention.

However, the practicalities of administering questionnaires to participants from both control and treatment conditions within a class or lecture environment were problematic due to possible contamination between conditions. Clusters of students were randomly assigned to either the control or treatment conditions. Where a year group had been split into several smaller groups for teaching purposes in a workshop, each group was randomly assigned to a condition. Where students from a particular course were not split into sub-groups, clusters of students (i.e. rows of students) were assigned to either the control or treatment conditions to reduce the effects of contamination between treatment and control conditions. The above strategy was used to limit the extent to which participants might discover that there were two separate conditions. Full details of the study including the two conditions, background to the research and how the data will be used were given during the debriefing of participants. Debriefing occurred straight after the post-intervention data was collected. For those who did not participate at the post intervention stage, the debrief was repeated during a compulsory lecture along with an email containing details of the study.

6.2.3 MATERIALS

Two questionnaire packs were constructed for the participants to complete during the collection of the first set of data at the beginning of the second term. The first pack was for those participants who were allocated to the treatment condition and the second was for those who were allocated to the control condition. The treatment pack consisted of a worksheet that asked participants to construct implementation intentions based on their own perceived barriers to mathematics as well as what they would consider to be effective strategies to improve their own mathematical ability. The control pack contained a different task that asked students to describe their feelings and understanding of infinity using words and pictures (see Appendix 2.9 for version A of the control and treatment interventions). Both versions of the question pack also contained an instrument for measuring the amount of mathematical study that the student engaged with outside of lectures (see Appendix 2.6 for details of Version B that was used in this intervention study). The questionnaire pack used to collect the second set of data contained two instruments: a mathematical study behaviours instrument (see Appendix 2.6 for Version B) and an alternate mathematics diagnostic test (see Appendix 2.4 for Version C). Further details of these instruments can be found in Chapter 4 (see Section 4.4).

6.2.4 Procedure

Participant data were gathered at three distinct time periods during the academic year to coincide with the three stages of pre-intervention, intervention and post intervention. Each stage used several instruments as shown in Table 6.1 (above in section 6.2.1) to either gather data or to perform an intervention. Actual dates and months between the three stages were different for each group of students as these were dependent on student and lecturer availability. In particular, those students who were enrolled on nursing courses had the greatest variation from the timings above as access to those students was based around not just university lectures but also their professional practice within hospitals. It follows that each student would ideally have completed all of the pre and post intervention instruments and one intervention worksheet (either the control or the treatment version). Data that were collected during the intervention part of the study used instruments to measure the participant's study behaviours and habits immediately prior to the administration of the interventions. The post-intervention data measured the students' performance on a mathematics diagnostic test and also their study behaviours and habits approximately 2 to 3 months after the intervention. An outline of the data collection process at both the intervention and post intervention stages is described below.

Intervention

1. Maximum of 20 minutes contact with students, intervention aimed at being

incorporated into a lecture or workshop

2. Random allocation of rows of students to either the control or treatment conditions (see Section 4.2.1 and 4.4.5)

3. Participants asked to check they have recorded their student number on their completed worksheet (1 minute)

4. Participants asked to complete the worksheet they have been given (5 minutes)

5. Researcher attempts to ensure that participants in the treatment group had properly created the implementation intentions as described on the worksheet in the form “if [] and [] then []”. This was accomplished by verbal reminders to all participants to check that the last question/instruction has been completed fully, without mentioning the content of the question.

6. Collection of completed worksheets

In all cases student numbers were replaced by the corresponding participant ID in a manner so as to render the student number unrecognisable.

Post-intervention

1. Maximum of 30 minutes contact time which aimed to either replace a typical

lecture time slot, incorporated into a lecture or appended to a lecture

2. Before proceeding a brief overview of the research was given to the participants of no more than 5 to 8 minutes (researcher handing out test instruments if this has not already been done).
3. Participants asked to complete the two instruments shown in Table 6.1 (15 to 20 minutes)
4. Participants asked to check they have recorded their student number on their completed questionnaires (3 minutes)
5. Collection of questionnaires

All data from the questionnaires were transferred into a spreadsheet and identified using the participant ID.

At the completion of each of the three stages where data collection had taken place, students were all given a verbal description of the overall purpose of the research. However, as the control and treatment conditions were in the same room it was not possible to discuss the individual tasks. All students were reminded that the research would take place over one academic year and that should they have any questions or concerns regarding the execution of the study they could contact the researcher or the supervisor via email or telephone.

At the post-intervention stage (after the data was collected) all students were provided with full information about the two conditions (treatment and control) and the associated tasks. All students were provided with a written hand-out that gave details of the potential benefits of the intervention and how they could create implementation intentions to aid goal-directed behaviour. After a preliminary analysis of the data had been conducted, the findings of the study together with an outline of the theory behind it were given to the lecturers of the students who had taken part, to provide additional information for those who required it. All of the completed paper questionnaires and keys (lists associating participant name to participant IDs) were kept for four weeks before being destroyed. During the four weeks after the post-intervention data collection, participants had the opportunity to withdraw from the study (their data removed and destroyed completely). Four weeks after the completion of the post intervention stage, all paper questionnaires and keys were destroyed.

6.3 Results

The intervention data collected during Study 2 aimed to capture the study habits of participants before and after the creation of implementation intentions in the treatment group (or completion of the dummy intervention in the control group). During the data collection process, two major issues were encountered that impacted on the analysis that was carried out. The first was that, as with the previous study, the data were not normally distributed. Secondly, there was a high level of participant attrition across the study. The two sections that follow deal with each of these issues in turn.

6.3.1 *Normality and statistical tests*

Longitudinal data from participants, consisting of study behaviour data (Term 2) supplemented by personality data from Term 1, were tested for normality. Kolmogorov-Smirnov tests for normality were conducted and showed that the personality variables and study behaviour data were not normally distributed (see Appendix 3.2). Non-parametric/robust tests were therefore used first to test the hypotheses. Kolmogorov-Smirnov tests for normality were carried out and suggested that the distributions of psychoticism and usage of the Mathematics Support Centre (intervention and post) were significantly far from normal indicating that non-parametric tests should be used (see Appendix 3.3).

6.3.2 *Participant attrition*

Due to the data being collected at three time points during the academic year, it was possible for student attrition to have an effect on the number of participants taking part in the study, resulting in a smaller than expected sample size. Furthermore, there was concern over possible bias in the sample. Available data may not have been representative of students who had not provided complete data. Complete study behaviour data was only available for 16% of the original sample. A comparison of the available data between participants with and without complete data on study habits was made (see Table 1 in Appendix 3.3) in order to ascertain if there was a statistically significant difference between these two groups.

The two groups were compared on the variables of Age, Gender, year mathematics qualification was achieved, mathematics diagnostic score and personality. Analysis of the data suggested that the only significant difference between the two groups was on the extraversion scores. Extraversion scores were higher for those who provided incomplete study habit data (*Mdn* = 17) compared to those with complete study habit data (*Mdn* = 14.5), $z = -2.581$, $p < 0.01$, $r = -0.153$. This suggests that even after the high drop out rate, the resulting small sample was likely to be broadly representative of those students who did not provide complete data. However, the sample is not representative in terms of participants' levels of extraversion. It should be noted that assumptions based on the above comparisons need to be viewed with caution as the data on study habits were obtained from the second and third questionnaires whereas mathematics diagnostics, demographic and personality data were obtained from the first questionnaire only. As such it is difficult to compare participants providing complete data on study habits (e.g. those completing both questionnaires in Term 2) with those providing incomplete data (e.g. completing only questionnaires during Term 2). In light of the potentially biased sample (particularly with regards to extraversion scores) it was decided to focus any analysis involving personality on psychoticism and not extraversion. Furthermore, it is acknowledged that the bias in the sample may not be limited to just extraversion, so generalisation of the results presented needs to be done with caution.

The intervention data were originally to be categorised into three groups based on the condition (treatment or control) and whether they had written down an implementation intention on the treatment version of the questionnaire they had been given. Due to the high level of student attrition it was decided not to split the treatment group into those who had written down an implementation intention and those who had not. However, before combining the data from the treatment condition it was necessary to ascertain that there were no major differences between participant who had and had not formed implementation intentions in the treatment condition. If there were, then it would have been unwise to merge the treatment data. The data on study habits from the three groups (control, treatment who had formed implementation intentions and treatment who had not formed implementation intentions) is summarised in Table 6.3 (below).

Table 6.3: Mean and median number of hours studied (Actual, Aspirational and Estimated) by participants in all conditions

Condition	Actual		Aspirational		Estimated	
	Before	After	Before	After	Before	After
Control	15.28	15.82	19.97	18.71	15.24	14.82
N = 33	(16.77)	(22.09)	(21.04)	(21.33)	(18.42)	(19.82)
Median	*11*	*13*	*14*	*13*	*6*	*10*
Treatment (no II*)	10.55	18.50	18.63	13.59	13.55	10.77
N = 11	(11.67)	(16.27)	(18.54)	(13.97)	(15.37)	(11.65)
Median	7	14	8	12	6	9.5
Treatment (with II*)	11.79	16.85	15.94	23.0	13.29	19.06
N = 17	(14.25)	(17.28)	(22.24)	(26.17)	(18.23)	(22.24)
Median	5	11	6	17	5	10

*II = implementation intentions,

Looking at the median scores suggests that there were some differences between the three groups and that statistical tests would need to be carried out to assess if these differences were statistically significant. Six Mann-Whitney U tests were conducted to test the differences in study behaviour measures between the groups who had explicitly written down their implementation intentions and those who had not within the treatment condition. The results suggested that there was no significant difference between these two groups on the measures of actual (U = 91.0, z = -0.118, p = 0.917, r = -0.022), aspirational (U = 69.0, z = -1.157, p = 0.257, r = -0.219) and estimated (U = 84.5, z = -0.426, p = 0.684, r = -0.081) study habits before the intervention. Furthermore, no statistically significant differences were found on the measures of actual (U = 89.0, z = -0.212, p = 0.844, r = -0.040), aspirational (U = 78.0, z = -0.742, p = 0.471, r = -0.140) and estimated (U = 78.0, z = -0.735, p = 0.475, r = -0.139) study habits after the intervention. As the tests suggested there was no difference between the students who had explicitly written down the implementation intentions and those who had not on the self-reported measures, the data from the groups was combined for the remaining analyses. Consequently the data were analysed according to condition only (control or treatment) and are presented in the summary statistics of Section 6.3.3.

6.3.3 Summary Statistics (Intervention data)

Due to the non-normality of the data (see Section 6.3.1), non-parametric/robust tests were used to test the following hypotheses:

1. Participants who constructed implementation intentions would report a significantly greater increase in the amount of time spent engaged with

mathematical study than that reported by those students who participated in the control condition.

2. The difference in the amount of time spent engaged with mathematical study between pre and post test would be negatively correlated with scores on the psychoticism scale (control and treatment conditions)

3. The difference in the amount of time spent engaged with mathematical study between pre and post assessment would be negatively correlated with participants' scores on the mathematics diagnostic test (control and treatment conditions)

Details of the mean and median number of hours of mathematical study, mathematics diagnostic scores and psychoticism scores are displayed in Table 6.4 below.

Table 6.4: Mean and median mathematics diagnostic test scores, psychoticism scores and hours spent studying by participants in the control and treatment groups before and after the intervention (Control *N* = 33, Treatment *N* = 28 except where indicated)

Condition	Maths Diagnostic*	Psychoticism**	Extraversion**	Actual		Aspirational		Estimated	
				Before	After	Before	After	Before	After
Control, *N* = 33	5.52	7.41	16.14	15.28	15.82	19.97	18.71	15.24	14.82
(S.D.)	(1.89)	(5.19)	(5.05)	(16.77)	(22.09)	(21.04)	(21.33)	(18.42)	(19.82)
Median	*5*	*6*	*19*	*11*	*13*	*14*	*13*	*6*	*10*
Treatment, *N* = 28	5.19	6.62	12.19	11.30	17.50	17.00	19.30	13.39	15.80
(S.D.)	(2.07)	(4.50)	(4.45)	(13.09)	(16.61)	(20.67)	(22.36)	(16.87)	(18.98)
Median	*5*	*6*	*11*	*5.5*	*12*	*7*	*15*	*5*	*9.5*
Control and Treatment, *N* = 61	5.39	7.08	14.47	13.45	16.59	18.61	18.98	14.39	15.27
(S.D.)	(1.95)	(4.86)	(5.14)	(15.20)	(19.62)	(20.75)	(21.63)	(17.6)	(19.28)
Median	*5*	*6*	*15*	*6.5*	*11.5*	*8*	*13.25*	*6*	*9.75*

*Control *N* = 25 and Treatment *N* = 16, **Control *N* = 16 and Treatment *N* = 16, the media number of Actual, Aspirational and Estimated number of hours are reported in italics.

Looking at the median data from Table 6.4 suggest that the largest increase was found in the actual number of hours studied by the treatment group (6.5 hours). The mean aspirational and estimated hours engaged in mathematical study were found to increase from pre to post assessment in the treatment group (8 hours and 4.5 hours respectively). In the control group, the aspirational hours of study decreased (-1 hours) and the estimated hours increased (4 hours). The difference in aspirational and estimated study times is illustrated more clearly in Figure 6.1 (below).

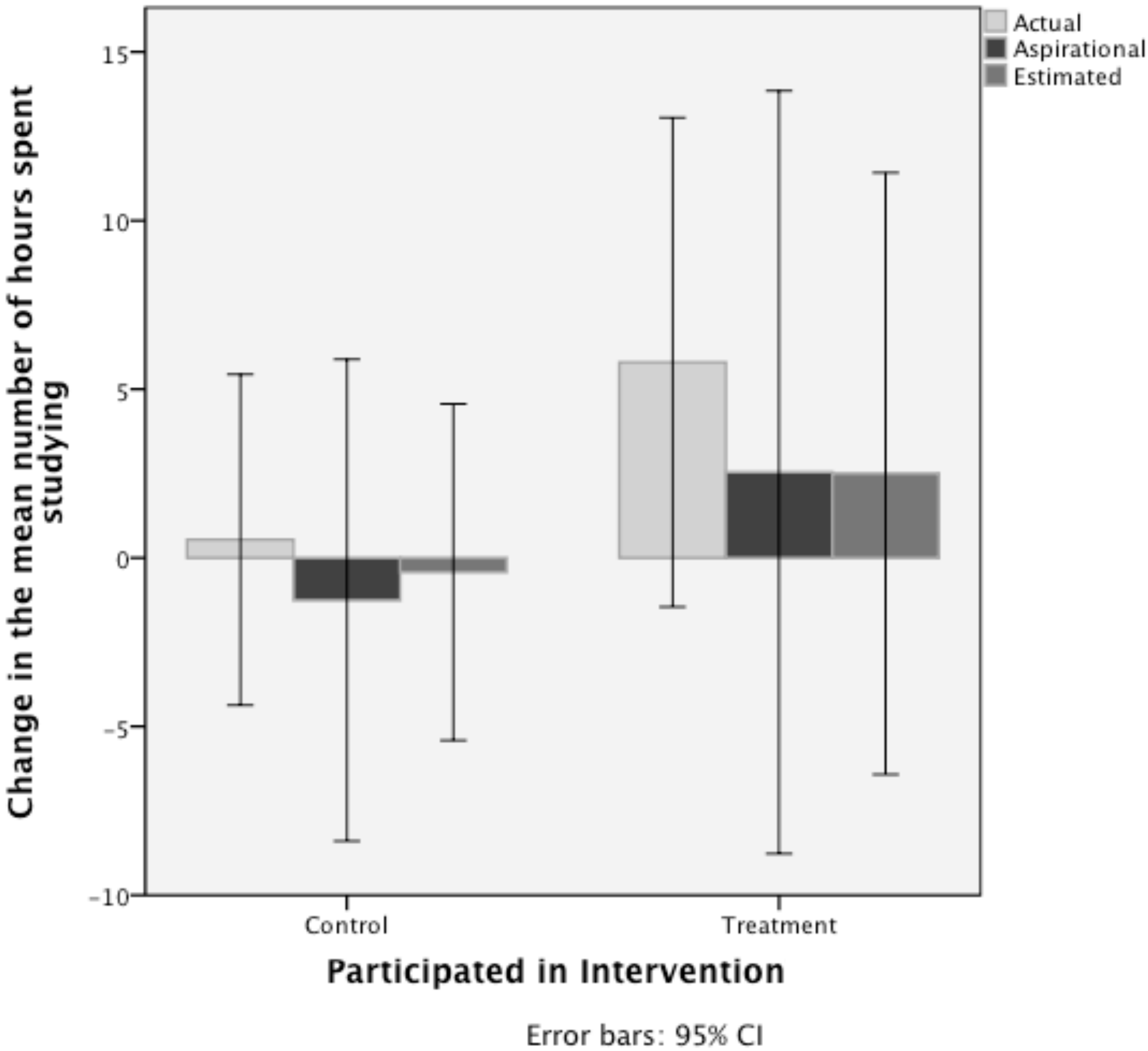


Figure 6.1: Changes in Actual, Aspiration and Estimated measures after the intervention (Control *N* = 33, Treatment *N* = 28)

The data were subdivided into those who had also taken part in the pre intervention stage of the data collection (see Section 6.2.1). This was done to check whether participation at the pre-intervention stage had an influence on the intervention data.

The mean number of hours for each of the study habits measures once the data had been subdivided is shown in Table 6.5 (below).

Table 6.5: Data on study habits split into those who had and had not participated in the pre-intervention stage of data collection

Participated in pre intervention	Group	Condition	Actual		Aspirational		Estimated	
			Before	After	Before	After	Before	After
No	1	Control*	9.13	11.75	9.8	14.56	7.13	11.31
		(S.D.)	(10.96)	(16.25)	(17.3)	(17.97)	(13.49)	(14.94)
		Median	*3.5*	*8*	*3*	*10.5*	*3*	*8*
	2	Treatment**	9.96	15.04	9.83	21.96	9.63	17.92
		(S.D.)	(11.89)	(17.54)	(12.85)	(27.63)	(13.89)	(22.15)
		Median	*5.5*	*8*	*6.5*	*19*	*5*	*12*
Yes	3	Control***	17.25	17.12	23.2	20.04	17.84	15.94
		(S.D.)	(17.98)	(23.79)	(21.4)	(22.47)	(19.24)	(21.29)
		Median	*13*	*12*	*20*	*15*	*15*	*10*
	4	Treatment****	12.31	19.34	22.38	17.31	16.22	14.22
		(S.D.)	(14.22)	(16.2)	(24.01)	(18.18)	(18.73)	(16.81)
		Median	*6*	*12.5*	*11.5*	*13.5*	*7*	*9.75*

The median number of Actual, Aspirational and Estimated number of hours are reported in italics.

**N = 8, **N = 12 , ***N = 25 , ****N = 16*

From the median data in Table 6.5 (as with that in Table 6.4) there does appear to be differences between the measures of study behaviours before and after the intervention. The increase in the median number of actual hours spent studying was greatest in the treatment group who had also participated in the pre intervention stage (6.5 hours). The same level of increase was not found in those in the treatment condition and had not been involved in the study at pre intervention (2.5 hours in Group 2). Greatest increases in the aspired number of hours spent studying were found in participants from the treatment condition who had not taken part at the pre intervention stage (12.5 hours in Group 2).

An examination of the means and medians suggested that the two measures show contradictory interpretations of the data. For example, the data from the treatment group who had also participated in the pre intervention stage (Group 4) suggests that the aspired and estimated hours of study decreased when the means were examined. However, looking at the medians for participants in treatment group who had formed implementation intentions suggests that both aspirations and estimated measures of study increased after the intervention. Such a large difference in the conclusions drawn from the means and medians suggests that means are not a good measure of central tendency for the data collected in this study. As the data was positively skewed and deviated significantly from a normal distribution it is likely that the extreme values of the amount of time engaged with mathematical study had a strong effect on the mean. The median is less affected by extreme values and as such was chosen to be a better measure in this study.

Thematic analysis of the situational cue data comprising of when or where an individual would engage in mathematical study related behaviours from those in the treatment condition (*N* = 28) was carried out. The analysis showed that 5 participants stated a specific day of the week (18%), 4 participants planned to study in the library (14%), 5 participants planned to study in the evenings (18%), 7 participants planned to study at lunch times (25%), 12 participants aimed to study with a friend (43%), 6 participants planned to study at home (21%), 2 participants thought to use the Maths Support Centre (7%) and 10 participants planned to use non-compulsory support workshops (36%).

6.3.4 Effectiveness of implementation intentions

To test whether the participants' implementation intentions had been effective in increasing the amount of time spent engaged in mathematical study, Wilcoxon Signed Ranks Tests were initially carried out on the data presented in Table 6.4 to ascertain whether there was a significant difference in the number of hours spent studying mathematics before and after the intervention for both control and treatment groups. Cohen's d was calculated using estimates of the effect size as described in Rosenthal (1991: 19-20). It was found that for participants in the treatment group, the amount of time spent engaged in mathematical study post-intervention (*Mdn* = 12) was significantly higher than at pre-intervention (*Mdn* = 5.5), $z = -1.750$, $p < 0.05$, $d = -0.481$. However, for the control group there was no significant difference between the time spent studying mathematics post intervention (*Mdn* = 13) and pre intervention (*Mdn* = 11), $z = -0.381$, $p = 0.356$, d = -

0.094. However, when the amount of improvement in study time (post test minus pre test) in each group was directly compared (Mann-Whitney) the difference between control (*Mdn* = 0) and treatment groups (*Mdn* = 1.5) failed to reach statistical significance, z = -1.123, p = 0.133, d = -0.291. Based on the data presented in Table 4.1 (see Chapter 4) and using N = 61, it would have been necessary to have in excess of 200 participants to have been able to observe a small to medium effect as was found in this study with a power of 0.7.

Examination of the *aspirational* and *estimated* study hour figures in Table 6.4 and Figure 6.1 suggested that post intervention values increased within the treatment group and decreased in the control group. However, these differences were not statistically significant. For the control group there was no significant difference between the aspirational times post intervention (*Mdn* = 14) and pre intervention (*Mdn* = 13), z = -0.009, p = 0.993, d = -0.003. Changes in the estimated study times (control group) were also found to be statistically not significant from pre intervention (*Mdn* = 6) to post intervention (*Mdn* = 10), z = -0.519, p = 0.603, d = -0.197. Similarly for the treatment group, increases in the aspiration times from pre intervention (*Mdn* = 7) to post intervention (*Mdn* = 15), z = -0.578, p = 0.563, d = -0.202. The estimated number of hours to be studied by those in the treatment condition at pre intervention (*Mdn* = 5) were not significantly different from those at post intervention (*Mdn* = 9.5), z = -0.543, p = 0.587, d = -0.19. This would suggest that the intervention is only useful for changing actual behaviours rather than an individual’s intended (aspirational) or estimated level of future study.

The above analysis (Wilcoxon Signed Ranks Tests) was repeated on the subdivided data as presented in Table 6.5 to ascertain whether there was a significant difference in the number of hours spent studying mathematics before and after the intervention when taking account of the prior participation in the study at the pre intervention stage. The results of the analysis is presented in Table 6.6 (below).

Table 6.6: Wilcoxon Signed Ranks Test statistics (z) for the differences between data on study habits gathered before and after the intervention of implementation intentions

Participated in pre intervention	Group	Condition	Actual	Aspirational	Estimate
No	1	Control	-0.734	-0.840	-1.472
		N = 8	*-0.537*	*-0.622*	*-1.219*
	2	Treatment	-0.593	-1.478	-0.969
		N = 12	*-0.347*	*-0.944*	*-0.583*
Yes	3	Control	0.000	-0.443	-0.209
		N = 25	0	*-0.178*	*-0.084*
	4	Treatment	-1.552	-0.692	-0.063
		N = 16	*-0.842*	*-0.351*	*-0.032*

**p* < 0.05*, **p* < 0.01 *(2-tailed), estimates of Cohen's d are reported in italics*

The results shown in Table 6.3 were all found to be not significant statistically. This suggests that the effect of taking part in stage 1 of the data collection did not have an effect on the subsequent intervention data. It should be noted that due to the high level of student attrition combined with the subdivision of the data, N was small for all of the subgroups and as such there was a reduction in the power of the tests.

6.3.5 *Personality and the change in time spent engaged with mathematical study*

It was hypothesised that participants who scored higher on the psychoticism scale would exhibit the least increase in the number of hours spent studying mathematics post intervention. Due to the small sample size and data being non-parametric, Kendall's tau was used to look for a correlation between psychoticism and the difference in the number of hours spent engaged with mathematical study between the beginning and end of the intervention period. Kendall's tau rather than Spearman's rho were examined due to the high proportion of repeated data values. Kendall's tau correlation coefficients are shown in Table 6.7.

Table 6.7: Kendall's tau correlation coefficients between scores in the EPQ-R personality scales and the differences in self-reported measures of usage (before and after the intervention).

Personality Measure	Condition	N	Actual	Aspirational	Estimate
Psychoticism	Treatment	16	-0.313*	-0.088	-0.253
	Control	22	-0.023	0.040	0.054
	Control and Treatment	38	-0.122	-0.006	-0.055
Extraversion	Treatment	16	-0.017	0.182	0.017
	Control	22	-0.037	0.060	0.033
	Control and Treatment	38	-0.066	0.072	0.012
Neuroticism	Treatment	16	0.111	-0.017	0.017
	Control	22	0.155	0.154	0.089
	Control and Treatment	38	0.136	0.102	0.072

*Significant at the p < 0.05 level (1-tailed)

There appears to be a weak but significant negative correlation between psychoticism and the increase in the actual number of hours the participants (treatment group) were engaged in mathematical study. The original hypothesis is supported by this evidence as it was hypothesised that those who scored higher on the psychoticism scale would be less able to follow through with mental plans i.e. in this case the formation of implementation intentions. There seemed to be no significant correlation between psychoticism and actual improvements in the study habits in the control group or across the sample of participants as a whole. A similar analysis of the extraversion and neuroticism variables found no significant correlations between them and the degree of improvement in the amount of time engaged with mathematical study between intervention and post-test. With regards to Aspirational and Estimated hours of study, there seemed to be no significant difference in Aspirations and Estimates before and after the intervention in either group. This would suggest that the intervention is only useful for changing actual behaviours rather than an individual's intended (aspirational) or estimated level of future study. A correlation analysis between the personality measures and self-reported study behaviours both before and after the intervention is presented in Table 6.8 (below).

Table 6.8: Kendall's tau correlation coefficients between scores in the EPQ-R personality scales and the self-reported measures of usage before and after the intervention.

Personality Measure	Condition	N	Actual before/ after	Aspirational before/after	Estimate before/after
Psychoticism	Treatment	16	0.152/ -0.220	0.053/ 0.100	0.106/ -0.053
	Control	22	-0.041/ 0.036	0.032/0.032	-0.032/-0.083
	Control and Treatment	38	0.048/ -0.060	0.038/ -0.061	0.020/ -0.155
Extraversion	Treatment	16	-0.141/ -0.113	-0.276/ -0.108	-0.270/ -0.209
	Control	22	0.037/ 0.098	-0.033/ -0.028	0.019/ -0.109
	Control and Treatment	38	0.004/ -0.086	-0.118/ -0.084	-0.119/ -0.012
Neuroticism	Treatment	16	-0.079/ 0.086	-0.129/ 0.107	-0.043/ 0.139
	Control	22	0.266/ 0.233	0.265/ 0.208	0.213/ 0.154
	Control and Treatment	38	0.021/ 0.218**	0.027/0.186	0.077/ 0.156

*Significant at the $p < 0.05$ level (1-tailed), ** $p = 0.03$

The results from the analysis presented in Table 6.7 suggested that implementation intentions were only effective for changing actual study behaviours. They also suggested that the change would be greatest for those scoring lowest on the psychoticism scale. The data from Table 6.8 suggests that regardless of the condition there was no correlation between personality and any of the measures of study behaviours collected before or after the intervention. Neuroticism was found to correlate, however no directional hypothesis was made and as such the resulting correlation is not statistically significant (two-tailed test).

6.3.6 Mathematical ability and the change in time spent engaged with mathematical study

Kendall's tau was calculated to see if there was a correlation between mathematical ability score and the change from pre to post-test in the number of hours spent engaged with mathematical study. Table 6.9 shows the correlations between the mathematics diagnostic score with differences (between before and after the intervention) in the actual, aspirational and estimated hours spent studying. The actual number of hours represents the time the participant was actively engaged with mathematical study during a one-month period. The aspirational number of hours of study was an indication of how much time a participant would like to study mathematics during a one-month period. Predictions of estimated study behaviours were an indicator of how much time an individual thought they could realistically spend studying in a given month in the future. The estimate differed from the aspirational times in that they aimed to not be optimistic or inflated, but rather, realistic values based on knowledge of personal barriers to study.

Table 6.9: Kendall's tau correlation coefficients between the mathematics diagnostic scores and the differences in self-reported measures of usage (before and after the intervention).

Condition	N	Actual	Aspirational	Estimate
		Correlations between mathematics diagnostics scores and the difference between before and after measures of study behaviours		
Treatment	16	0.098	0.081	0.250
Control	25	-0.089	-0.082	-0.090
Control and Treatment	41	-0.080	-0.032	0.036
		Correlations between mathematics diagnostics scores and study behaviours both before and after the intervention reported as before / after.		
Treatment	16	-0.009/ 0.072	0.045/ 0.028	0.009/ 0.172
Control	25	-0.193/ -0.306*	-0.181/ -0.247	-0.166/ -0.130
Control and Treatment	41	-0.91/ -0.168	-0.080/ -0.109	-0.075/ -0.004

*Significant at the $p < 0.05$ level (1-tailed).

From the data in Table 6.9 it can be seen that none of the observed correlations between mathematical ability (before the intervention) and the change in the actual time spent engaged in mathematical study were statistically significant; this was the case in both treatment and control groups. However, Table 6.9 does suggest that after the intervention there was a statistically significant correlation between the actual amount of mathematical study and the initial mathematics diagnostics scores for those in the control group.

6.4 Discussion

The results suggest that, in line with past research (Webb and Sheeran 2007, Gollwitzer 1999 and Casper 2008) and the original hypothesis, the creation of implementation intentions did seem to promote the performance of goal-related behaviours. Participants who constructed implementation intentions showed significant increases in the amount of time spent studying mathematics from pre to post-test and the same level of increase was not observed for those who had not constructed implementation intentions. However, direct comparison of the amount of change from pre to post-test between the two groups failed to reach statistical significance, suggesting that the effect of the intervention was not as strong in this context as has been reported in other studies (Webb, Christian and Armitage 2007). Furthermore, it is important to note that the high level of variation in data combined with the small sample size made it harder for a significant result to be achieved. The data also suggested that the creation of implementation intentions was not effective in changing an individual's intention to study (changes in aspirations and estimates of study behaviours were not statistically significant).

The ability to carry out a plan and self-motivate towards a goal has been attributed to the psychoticism/ conscientiousness personality trait (Eysenck 1991). Furthermore, this personality trait was suggested to be correlated with academic achievement (de Fruyt and Mervield 1988). In light of previous research it was inferred that it could, in part, be responsible for the ability to adhere to study plans. The data partially supported this hypothesis as there was a weak negative but significant correlation between the level of psychoticism and the increases in actual time spent engaged in mathematical study for the treatment group only. No other significant correlations were observed between psychoticism and differences in the other measures of study behaviour in any of the groups. The original hypothesis also suggested that those students who scored lowest on the mathematics diagnostic test would show the greatest increases in study behaviour after the formation of implementation intentions. However, data from this study did not support this hypothesis. The possible reasons for this overall pattern of findings are explored below.

Previous literature (Webb and Sheeran 2007, Gollwitzer 1999, Casper 2008) predicted that the use of implementation intentions would increase study behaviour. The data from the study presented in this chapter provides some evidence that the study behaviours of participants did increase after the formation of implementation intentions (Section 6.3.4 and 6.3.5). However, the results need to be interpreted with caution due to the small sample size and variations between baseline measures of study habits between the control and treatment conditions. The literature also suggested that the formation of implementation intentions does not necessarily bridge the gap between intention and behaviour but rather increases goal-directed behaviour through enhancing or forming cue-behaviour links (Gollwitzer 1999). This could explain why the participants in the treatment condition were found to have spent a significantly greater time engaged in mathematical study after having identified a time/place where they could be able to engage in a study behaviour that would result in increased mathematical ability. Furthermore, the implementation intentions only had an impact on the *actual* amount of time spent studying; this would appear to agree with the literature in that the formation of these plans only affects the cue-behaviour link and in a sense bypasses the intention. This explains why neither the aspirational or estimated study times showed a significant change in the treatment group post intervention. The lack of observed change in intentions was also found by Webb and Shreeran (2008) whose meta-analysis explored how the formation of implementation intentions influence individual self efficacy and intentions. The analysis suggests that implementation intentions had little to no effect on either intention to study or self-efficacy. The implementation intentions served as a link between an external cue and a desired behaviour with the aim of helping an individual to perform a specific type of behaviour in line with their own intentions. As a result it is to be expected that the formation of implementation intentions do not change intentions but only help to facilitate the intended behaviour.

The literature has also suggested that personality could act as a potential moderating factor in the effectiveness of implementation intentions. Psychoticism was found to be negatively correlated with the increase in the actual number of hours participants studied mathematics outside of formal classes. Furthermore, the increases in the number of actual hours spent studying mathematics was only found to be statistically significant for those participants in the treatment condition. This suggests that psychoticism could be a factor in the ability to form implementation intentions. However, the correlations between psychoticism and measures of study behaviour before and after the intervention were not found to be statistically significant. The literature suggested that those who scored low on the conscientiousness scale tended to benefit most from the construction of implementation intentions (Webb et al. 2007). The weak negative correlation observed by Lodhi, Deo and Belhekar (2002) between psychoticism and conscientiousness suggests that those who score high on psychoticism and low on conscientiousness would be more inclined to work individually, less disciplined and less goal orientated (Eysenck 1991).

This type of behaviour could explain why the improvements in actual study times were negatively correlated only with students in the treatment group as those were the only ones who had formed implementation intentions. However, it is unclear why no correlations between study habits before or after the intervention were found in either of the conditions. One explanation for this could be that students who took part in the study did not have any intention or plans to study mathematics outside of taught classes.

No correlation was observed between the increase in the number of hours students were studying mathematics over the course of the study and mathematics diagnostic scores. Although individuals may have been motivated by their perceived mathematical self-efficacy to either increase or decrease the amount of time spent studying mathematics, it is suggested that this motivation to work harder (or not) is more in line with an intention to study rather than an actual behaviour. As discussed earlier the implementation intentions work by enhancing or forming cue-behaviour links, in essence the initiation of the behaviour could be due to the environmental cue identified during the intervention rather than from motivation (or lack of it) based on their perceived mathematical abilities. What is of interest is that the mathematical ability of the participants did not have an impact on the increase in the time students were engaged with mathematical study whereas the level of psychoticism did (treatment group only), although this does not imply causality. It was hypothesised that the individual’s own perceived mathematical needs would limit the extent to which the treatment was effective, however the data does not support this. Analysis of the data also suggests that the implementation intentions did not have any effect on the aspirations or estimates of future study of the participants indicating that the use of implementation intentions is useful for increasing goal-related behaviours but may not be as useful for initiating changes in attitudes or increasing motivation (changes were observed in Table 6.9 however these were not statistically significant).

It is acknowledged that within this study there were a number of methodological limitations in addition to those resulting from a small sample size. One of the consequences of the small sample size was the impact on subsequent analysis. All data had originally been categorized into three groups based on the condition (control or treatment) and whether they had formed implementation intentions or not. The reason behind this strategy was to ascertain if any improvements in the treatment condition were due to the formation of implementation intentions or by the identification of barriers to study and/ or appropriate study strategies. The differences in self-reported study behaviours between participants in the treatment group who had and had not explicitly formed implementation intentions were found to be not statistically significant. This could suggest that forming implementation intentions had no effect on the study behaviours of the participants. It could also suggest that the effectiveness of implementation intentions is unaffected if participants do not explicitly write down on paper the implementation intentions. However, it should be noted that there was no way to identify between those who had formed implementation intentions and not written them down from those who had not formed them in the treatment condition. Furthermore, the reduced sample size in the treatment group could have been influential in this result. A better approach for a future study could be to have three distinct conditions, one treatment group (guidance on how to form implementation intentions), and two control conditions (one neutral task while the other involved a similar task to the treatment group without the end result of an implementation intention). An improvement for remedying the small groups sizes in a future study would be to reduce the level of student attrition perhaps by considering student attendance variation throughout the year and collecting data when student engagement is high.

The data suggested that types of cues identified when creating implementation intentions of participants included studying with a friend (43%) or using supplemental workshops run by the university (36%). Examination of the relative ease of engaging with the different study methods was not possible due to the small sample and was consequently not looked at in this study. A larger sample would have allowed both of the above to be explored more easily. For example an individual who identifies a particular time of day would have more opportunities to perform a goal-directed behaviour compared to another individual who had identified a single day of the week as his/her cue. This argument could also be extended to the locations and types of behaviour being measured using the study behaviours questionnaire. Although it seems unethical to impose limitations on when or how frequently an individual would choose to study, a compromise could be reached by being more specific on the location of study that is being influenced by the intervention. By changing the instructions of the intervention to focus on just one location that is common to all of the participants then the study behaviour instrument could be modified to focus on only behaviours occurring in one particular location e.g. a support service being offered within the university. It may also be useful to consider the time of year when the participants' study behaviours are measured, in particular the proximity to exams and coursework deadlines, as this would influence the patterns of study and also the observable difference between a control and treatment group.

Furthermore, although there was no statistically significant difference between pre and post intervention measures of actual study behavior within the control group, there was a noticeable reduction in the time spent engaged in mathematical study. The reduction could be attributed to the control condition task having a detrimental effect on the participants' future study behaviours. However, there is no evidence to suggest that the control task had a negative impact on students' engagement with mathematical study. The task asked students to talk about their interpretations and understanding of the word infinity. The feedback from participants during their debriefing did not indicate that students interpreted this as a mathematical question. Reviewing the answers given by students indicated that students tended to give interpretations in theological contexts in addition to the common themes of 'unending', 'forever' and 'repeating endlessly'. A future study would benefit from having a more neutral task, possibly involving no mathematical content. However, it should be noted that any observed reduction in the study habits of students in the control group after the intervention was not statistically significant and as such there was no evidence to suggests a change in the control task was required. The analysis could also benefit from a larger sample size to increase power and chance of detecting small to medium effects.

The use of a regression analysis would assume that all of the variables were interval, normally distributed residuals with linear relationships between the predictor and dependent variables. The data obtained from this study did not meet all of the assumptions, particularly that of linearity and normally distributed residuals. Performing a regression would thus have resulted in erroneous results and the inability to obtain accurate significance and confidence intervals for the regression coefficients. It is suggested that the type of data being collected is inherently non-parametric and alternative methods of analysis must be used. An alternative option would be to use non-parametric regression if the sample size was significantly larger.

6.4.1 Implications

The results of this study suggest that the creation of implementation intentions could potentially increase the amount of time spent engaged in mathematical study, but the results are not as robust as has been found in previous studies. The observed increases were most evident for those who scored lower on the psychoticism scale. Increased study behaviour was not correlated with the initial mathematics ability of the students. The data also suggested that the creation of implementation intentions was not effective in changing an individual’s intention to study (changes in aspirations and estimates were not statistically significant). The implications of the longitudinal study for supporting students who attempt to engage in mathematical study are:

- Asking students to create implementation intentions can increase the amount of time spent engaged with study. However, it is necessary to highlight that based on this study it is those who have lower scores on the psychoticism scale who will benefit the most regardless of their mathematical ability.
- Those students of most concern are the ones who score lower on the diagnostic tests. This would then suggest that those who tend to score lower on mathematics tests and score highly on the psychoticism scale would benefit the least from the creation of implementation intentions if used as the sole method for increasing study time.

CHAPTER 7 EVALUATION OF THE EFFECTIVENESS OF IMPLEMENTATION INTENTION FORMATION ON MATHEMATICS SUPPORT CENTRE USAGE

This chapter describes Study 3, which took place during the academic year 2009 to 2010. The aim of this study was to first address the student attrition that was experienced during the data collection for the previous study and secondly to focus on a more specific behavioural goal. Where the previous study had focused on the general mathematical study habits of the participants in a variety of contexts (e.g. at home, library, Mathematics Support Centre) where the student may have wished to engage with mathematical study, the One Term Long Intervention Study examined the study behaviours that were focused in one particular location (the Mathematics Support Centre). The data from this study suggest that implementation intentions are ineffective at increasing the amount of time students spent using the Mathematics Support Centre. Furthermore, the data suggested that improvements in the usage of the Mathematics Support Centre were unrelated to the students' mathematical ability or their personality. Students' initial aspirations about using the Mathematics Support Centre were the greatest indicator of how much students would increase their usage of the mathematics support services or not.

7.1 RATIONALE

Due to the high participant attrition observed in the previous study (Section 6.3.2), a smaller than expected sample size was obtained for exploring the effectiveness of implementation intentions. Complete study behaviour data were only available for 61 participants across the five subject groups (Business Foundation Year, Business Management, Adult nursing, Psychology and Sports). It was thus deemed necessary to collect further data during the 2009 to 2010 academic year.

The literature described in Chapter 2 suggested that one strategy for potentially raising the mathematical ability of new undergraduates would be their use and engagement with mathematics support services. As was highlighted by Grehan, Mac an Bhaird and O'Shea (2010), the use of Mathematics Support Centres can increase the chances of increasing mathematical attainment. However, as Symmonds, Lawson and Robinson (2008) found, the potential benefits of using these services are only realised if students engage with the services. Symmonds, Lawson and Robinson (2008) and Grehan et al. (2010) found that the weaker students were the ones who were not engaging with the services. Furthermore, it was found that students studying Health and Life Sciences accounted for less that 4% of the users of the mathematics support services in higher education institutions (Lawson, Croft and Halpin 2001). The literature further suggested that conscientiousness could influence the effectiveness of implementation intentions (Webb, Christian and Armitage 2007). This study therefore aimed to build on the results of the previous intervention study by focusing the intervention on the usage of the Mathematics Support Centre rather than mathematics study habits in general, and addressing some of the methodological weaknesses of the study with respect to attrition rates / sample size.

With respect to the assessment of the psychoticism trait which appeared to be moderating the effectiveness of the intervention in the previous study, it is acknowledged that the NEO personality inventory would have been preferable to the EPQ-R as it would have enabled the direct measurement of the conscientiousness personality trait. However, a decision was made to use EPQ-R instrument as before as it was both shorter and would allow a direct comparison to be made with the results from the previous study described in Chapters 5 and 6. The results of the study reported in this chapter primarily aim to ascertain whether implementation intentions have a positive effect on improving the actual usage of Mathematics Support Centres by students from health and life science disciplines. Secondly, the study aimed to assess the possible moderating effects of personality and mathematical ability on the effects of forming implementation intentions within the context of extra-curricular mathematical study. These research questions were answered by testing the following hypotheses a) Only participants who constructed implementation intentions would show a significant increase in the amount of time spent engaged with mathematical study; and b) Increases in the time spent engaged with mathematical study would be negatively correlated with scores on the psychoticism scale.

Furthermore, psychoticism and mathematics diagnostics data were examined to explore differences in scores between students from different courses (similar to the analysis from the first phase of previous study (see Chapter 5). The relationship between both personality (psychoticism and extraversion) with Mathematics Diagnostics Scores was also looked at. Both the literature and data from the previous study indicated an inconsistent relationship between extraversion and achievement. It was predicted that there would be a negative correlation between the psychoticism scores and the mathematics diagnostic test scores (in line with the literature and also the results of the data presented in Chapter 5). Furthermore, because of the results of the concurrent data obtained from the previous study (see Chapter 5) it was also predicted that there would be a statistically significant difference in psychoticism and mathematics diagnostic scores between students from different courses.

7.2 METHOD

As the previous study suffered from high student attrition over the course of the academic year, this study offered the opportunity to gather data from a larger sample of participants, and also provided the chance to improve the instruments and streamline the data collection strategy further to reduce the effect of student attrition. Rather than collecting data over the course of the year (using three assessment points), participants were required to participate in only two data collection sessions during the 1st term of the 2009 to 2010 academic year. Conducting a third study also allowed for changes to the instruments to reflect the change of focus of the intervention along with using the version of the mathematics diagnostic that was shown to have a higher reliability (see Section 4.4.1 of Chapter 4).

7.2.1 Design

A mixed design was used with the condition (two levels – control and intervention) and course being studied (three levels – Sports, Social Work and Psychology) used as between participants factors. The within participants factors (repeated measures) were the pre and post-intervention measures of study habits (the usage of the Mathematics Support Centre). The control variables of mathematics diagnostic scores, Marlowe Crowne and personality (EPQ-R scores) were all measured just once. The analysis of Marlowe Crowne data from Study 2 examined in Chapters 5 and 6 suggested that there was no evidence of social desirability bias in the responses of participants.

The data were gathered by collecting data at two time points during the first term of the academic year. The first questionnaire administered to the participants at the beginning of the first term (October) of the 2009 to 2010 academic year consisted of a version for those participants allocated to the control group and another version for those in the treatment group. In the previous study, all of the participants had been in their first year of study and as such it would not have been possible to gather accurate data on past study behaviours. Recruitment for the study described in this chapter was not limited to only first year students, Sports and Social Work students were all in their second year of study while the remaining students were all in their first year studying Psychology. Feedback from the course leader on the Sports and Social Work courses indicated that the students would be engaged with some statistics and research methods work as part of their course in the second year. This could have influenced the results of the maths diagnostic test and also baseline measures for usage of the Mathematics Support Centre. In this study, data was collected during the first term as the overall level of student attrition would have been higher had the study continued for longer than a term.

All participants (control and treatment conditions) completed the same version of the second questionnaire that was administered to participants between the middle and end of the first term of the same academic year (November to December). There was a gap of between 4 to 6 weeks between the administering of the first and second questionnaires.

7.2.2 Participants

Participants were recruited through collaboration with staff from courses and departments within the Faculty of Health and Life Sciences just as in previous studies. Staff running the Psychology, Sports Science and Social Work courses agreed to support the study by assisting with participant recruitment. In all cases, participants were recruited within lectures with the cooperation of lecturers. All students were given full details of the nature of the research, were told that participation was voluntary, and that withdrawal from the study was possible at any point during the data collection and up to a month after the data had been collected.

Recruitment of participants for this study was carried out in conjunction with the course leaders for all of the courses. As a result every effort was made to ensure that students who were recruited for this study were different from those who had participated in the previous studies (Chapters 5 and 6). Participants from all the courses were asked to write an X next to their student ID on their questionnaire if they had participated in the study previously. It should be noted that a better method would have been to remove data from these participants based on a comparison of the student ID with the key created in studies 5 and 6. However, this was not possible due to the destruction of the key after the study had been completed. Though no students identified themselves as having already taken part in a previous study, it does not rule out the possibility that participants may have forgotten their past participation in earlier studies. Had any participant already taken part, it would have been necessary to remove their data from the study due to the implications stated above. If participants had taken part in the previous study then it would have to be assumed that they were fully aware of the purpose of the study and also the tasks being given to participants in the two conditions and thus become aware of the condition they had been allocated to. The implications of previous participation would have been that they knew what the experiment was aiming to test for as well as what the researcher was looking for or hoping to find. By knowing of the two conditions, it is possible that the participants could contaminate the other data by divulging to the other students the two types of task being used in the control and treatment conditions. Furthermore, the participants could respond in a manner that is either in line with what they perceive would be expected from typical responses for their allocated condition or in a manner that is not.

All of the students were from the Faculty of Health and Life Sciences at Coventry University. Of the 276 participants who had volunteered to participate in this study, 204 participated in both parts of the experiment (pre and post intervention). Out of these 204 participants, complete data on study habits and personality data and mathematics diagnostic scores were available for 186 participants. Their details are given in Table 7.1 below (collectively and per subject group).

Table 7.1: Gender and mean age of participants across all courses and experimental conditions

Course		Male	Female	Undeclared	Total
All Courses*	N	50	134	2	186
	Age	20.44	20.33	N/A	20.36
	(SD)	(5.64)	(5.83)		(5.76)
	Control	17	62	1	80
	Treatment	33	72	1	106
Sports	N	8	10	0	18
2nd Year	Age	18.63	18.50	N/A	18.56
	(SD)	(0.92)	(0.85)		(0.86)
	Control	4	5	0	9
	Treatment	4	5	0	9
Social Work*	N	5	14	2	21
2nd Year	Age	35.80	29.93	N/A	31.40
	(SD)	(5.26)	(11.04)		(10.12)
	Control	3	4	1	8
	Treatment	2	10	1	13
Psychology	N	37	110	0	147
1st Year	Age	18.76	19.19	N/A	19.08
	(SD)	(1.92)	(3.42)		(3.11)
	Control	10	53	0	63
	Treatment	27	57	0	84

*Gender and age data not available for 2 participants

7.2.3 MATERIALS

Data were collected using only two questionnaires to help to reduce the effects of student attrition. The first questionnaire was administered to the participants very close to the start of the year, and the second was administered approximately one month after the first. Reducing the number of questionnaires from three to two resulted in a change in the instruments that were included in each questionnaire pack. The first questionnaire assessed Demographics (Version C), Mathematical Study Behaviours (Version C), Mathematics Diagnostics (Version C) and an intervention (either Control Version A or Treatment Version B). The second questionnaire comprised the Mathematical Study Behaviours assessment (Version C), the EPQ-R and the Marlowe Crowne scale.

The Mathematics Diagnostics instrument was only used once (rather than collected at pre and post-intervention) for two reasons. Firstly, the time taken to complete the questionnaires in the last study had been found to exceed 30 minutes for a number of participants. During the debriefing students had commented that a shorter questionnaire would have kept them on task and perhaps reduced the likelihood of students giving poor quality answers (i.e. without thought). Secondly, the data collection during this study would be taking place within a timetabled lecture or workshop and it was essential that the collection was completed within the 30 minutes to ensure as little disruption to the students' learning as possible.

Although the primary reason for conducting this study was to obtain a larger sample size, it also provided the opportunity to improve the demographics, mathematical study behaviours, mathematics diagnostics and treatment (intervention) instruments. These changes to the instruments were either for improved clarity or to reflect the change in focus of the treatment in the light of the findings from the previous study.

- Mathematics Diagnostic (Version C) – Two versions of the instrument were used during the previous study (Chapters 5 and 6). Both versions tested the same mathematical topics. Version C was designed to be an alternate version of the questionnaire rather than an improvement upon Version B. Version C was chosen for this study as it was found to have a better internal reliability compared to Version B (see Section 4.4.1). The sample used when calculating the reliability of the test was similar to the anticipated sample for this study in that they were all undergraduate students of approximately similar ages. The courses being looked at were also similar in both studies. In light of the similarities between the participants in the two studies, the decision to choose Version C was valid. However, it should be noted that the two samples were still different and that the previous sample only consisted of first year students and as such this could result in the reliability estimate not being valid for the current study. A recalculation of Kuder-Richardson's rho reliability indicator when using Version C of the diagnostic with the participants in this study yielded a value of 0.711. This value of 0.711 was similar to those obtained previously using this instrument.

- Intervention – The previous study used Version A of the treatment task, which guided the participants' formulation of implementation intentions such that the focus was on general mathematics study behaviours outside of timetabled lectures and workshops. However, the focus of this study was to facilitate participants' formation of implementation intentions that were aimed at specifically increasing their usage of the Mathematics Support Centre. The instructions on the treatment task were therefore amended to reflect this change and resulted in Version B of the treatment task (see Appendix 2.10). The intervention task for the control condition remained unchanged (Version A, see Appendix 2.9). The decision to keep the control task unchanged was informed by the result of the previous study which showed that any differences between pre and post-intervention study behaviours for participants in the control group were statistically not significant. This suggests that there is no evidence that the control task had helped to either improve or reduce the amount of time spent by these students in studying mathematics. Furthermore, keeping the control task the same would allow the results from this study to be directly compared with those from the previous study.

- Mathematics Study Behaviours (Version C) – Taking into account the change of focus for the treatment group intervention mentioned above, Version C of this instrument asked specifically about study behaviours within the context of the Mathematics Support Centre.

- Demographics (Version C) – This instrument was changed to improve clarity of the question items, in particular the removal of most of the free response items (all except the one asking for the year in which the participants' mathematics qualification was obtained). Removing the free response items reduced the amount of time required to complete the Demographics section of the questionnaire. It was also found that the free response questions did not add any useful information about the student that could not already be collected using multiple choice type question items.

7.2.4 Procedure

As with the previous study, data were collected before and after the implementation intentions based intervention. The intervention (either treatment or control) was administered to participants early in the first term of study. The questionnaire aimed to collect data on demographics, Mathematical Study Behaviours, Mathematics ability in addition to assisting with the administration of the treatment. Below is a brief outline of the data collection procedure using the first questionnaire.

Intervention (including pre-intervention measures)

1. A brief overview of the research was given to the participants (the

researcher handed out consent and test instruments. The participants were asked to first read the briefing information and, if happy to do so, complete the consent form (5 minutes)

2. What followed was a random distribution of treatment and control versions of the questionnaires to all participants. (worksheets were distributed to students, alternating between treatment and control based on seating arrangements where rows alternated between control and treatment conditions.)

3. The participants were then asked to complete the worksheet they had been given (25 minutes)

4. The researcher attempted to ensure that participants in the treatment group had properly created the implementation intentions as described on the worksheet in the form “if [] and [] then []”. This was accomplished by verbal reminders to all participants to check that the last question/instruction has been completed fully.

5. Participants were asked to check they have recorded their student number on their completed questionnaires (3 minutes).

6. The completed worksheets were collected and participants were thanked for their time.

After all of the completed questionnaires had been collected, each script was allocated a randomly generated three digit numerical participant ID. A key was constructed linking the student numbers to the participant IDs. All data from the questionnaires were transferred into a spreadsheet and identified using the participant ID. All questionnaires were then destroyed while the key was retained for use in the latter stages described below. In all cases the student number was replaced by the corresponding participant ID so that the responses from the student could not be traced back to any particular student without the use of the key.

The post-intervention data collection aimed to collect data on Mathematical Study Behaviours, personality (EPQ-R) and social desirability (Marlowe Crowne instrument). The procedure for carrying out the data collection post-intervention is outlined below.

Post-intervention (including post-intervention measures)

1. While the researcher handed out the consent forms a brief overview of the research (only a recap of the information provided at the intervention stage) was given to all of the participants taking part in the study. All participants were asked to complete and sign the consent form before being allowed to take part in the study. (5 minutes)

2. The post intervention questionnaires were distributed to the participants who had chosen to take part in the study and had completed the consent

form.

3. Participants were given 25 minutes to complete the worksheet/ questionnaire they had been given once they were briefed on its contents.
4. All of the participants were asked to check they have recorded their student number on their completed questionnaires and had signed the consent form. (3 minutes)
5. All of the worksheets were collected from the participants once it was ensured they had signed the consent form.

All data from the questionnaires were transferred into a spreadsheet and identified using the participant ID using the key created during the pre-intervention stage. At the completion of each of the two questionnaires, students were all given a verbal description of the overall purpose of the research. All students were reminded that the research would take place over one academic term and that any questions or concerns regarding aspects of the study could be raised with the researcher or supervisor through email or telephone (details of which were provided to all students). At the post-intervention stage (after all data were collected) all students were provided with full information about the two conditions (treatment and control) and the associated tasks. All students were provided with written handouts that gave details of the potential benefits of the intervention and how they could create implementation intentions to aid goal directed behaviour and importantly potentially improve their study habits. After a preliminary analysis of the data had been conducted, the findings of the study together with an outline of the underlying theory were given to the lecturers of the students who had taken part to provide additional information for those who required it. All of the completed paper questionnaires and keys (lists associating participant name to participant IDs) were kept for four weeks before being destroyed. During the four weeks after the post-intervention data collection, participants had the opportunity to withdraw from the study (their data removed and destroyed completely). Four weeks after the completion of the post intervention stage, all paper questionnaires and keys were destroyed.

7.3 Results

Of the 276 participants, pre-intervention usage data was available for 228 participants. 174 (71%) responded with data that suggested they had not spent any time using the Mathematics Support Centre during the past month. Of those who participated in the study, 186 participants provided complete study habits, mathematics diagnostics and personality data. A preliminary analysis also looked at the participants' adherence to the instructions given in the intervention, particularly the formation of implementation intentions. The preliminary analysis highlighted 18 students who had not completed the treatment questionnaire completely by writing down the implementation intentions they had formed. Their incomplete responses led to some doubt as to whether they had formed implementation intentions or not.

In light of the above their responses were removed from the data set (leaving 168 participants with complete data). Their data were not analysed as a separate group due to the sample size being relatively small. Furthermore, the remaining data were subdivided into that from participants who had aspirations to use the Mathematics Support Centre and those who had not (full details of this are given in Section 7.3.2.2). The main analysis that was carried out first compared the treatment and control groups. Furthermore, the data from each condition were subdivided into two groups based on how many hours the participants aspired to use the Mathematics Support Centre for prior to the intervention. Those who had responded with an aspiration equal to zero hours were placed in the first group while those who responded with an aspiration greater than zero hours were placed in the second group. This was done to take into account that some students may not have had the goal of wanting to spend more time using the Mathematics Support Centre.

7.3.1 Normality and statistical tests

Originally the assumption was made that the study behaviour data and personality variables would be close to being normally distributed. In those cases with mild violations, transformation of the dependent variables would have yielded normally distributed data. With that assumption, the intended analysis would have taken either the form of a mixed MANCOVA or a regression analysis. Doing so would have allowed for the identification of main effects and importantly interactions between predictor variables on the dependent variables. Furthermore, if certain predictors were found to explain significant variation in the dependent variables a model could have been formed that could predict the effectiveness of the treatment based on personality and mathematics ability scores at baseline.

Tests of normality were performed on the data for all of the measures across all sub groups. The data were generally found to deviate significantly from normality. Non-normality was the most problematic for the measures of usage where transformations would not be sufficient to make the distributions appear normal. The major concern was due to the distributions being either severely leptokurtic or both leptokurtic and skewed. The skewness could have been remedied through suitable transformations in some cases. However, the severity of the kurtosis could not be remedied through transformations.

Appendix 3.4.2 reports the results of the Kolmogorov-Smirnov tests for the data as grouped in the analysis reported in Sections 7.3.3 and 7.3.4. In light of the non-normal distributions, non-parametric methods were used to test both the effectiveness of the implementation intentions on changing the amount of time spent engaged in mathematical study within the Mathematics Support Centre, as well as the influence of mathematics ability and personality on the extent to which mathematical study behaviour (in particular those in the treatment group) was changed. Comparisons between groups involved Mann-Whitney U tests while within participant comparisons were performed using Wilcoxon Signed rank tests. Kendall's tau correlation coefficients were examined to assess the correlations between pairs of variables. Kendall's tau rather than Spearman's rho was used due to the number of repeated ranks in the data. The use of non-parametric methods were further justified as some of the variables used were not of the scale or nominal type (mathematics diagnostic, personality and Marlowe Crowne).

Rather than use standard non-parametric analysis that could lead to a large number of Mann-Whitney U and Wilcox Signed rank tests, the use of more modern methods of non-parametric analysis was considered. Such methods include the use of Rank Transforms (Conover and Iman 1981) where data are ranked according to size; standard parametric analyses such as analysis of variance are then carried out on the ranks rather than the actual data values. Such methods have the advantage that they are better suited to allow for the analysis of interactions between factors. However, Rank Transforms such as those described by Conover and Iman (1981) have been shown to have limited usefulness due to a lack of robustness (Erceg-Hurn and Mirosevich 2008) and unreliable results when examining interaction effects (Wobbrock, Findlater, Gergle and Higgins 2011). Better forms of Rank Transforms have been developed that are more robust and also more reliable when examining interaction effects, including The Aligned Rank Transform (Wobbrock, Findlater, Gergle and Higgins 2011) and the ANOVA-Type Statistic (Brunner and Puri 2001, Shah and Madden 2004). The effectiveness of the implementation intentions was measured by changes in the self-reported measures of actual usage of the Mathematics Support Centre. For the main analysis presented in this chapter the actual amount of time that participants had reported using the Mathematics Support Centre was transformed using the Aligned Rank Transform (ART) method and subjected to an ANCOVA analysis.

7.3.2 Summary Statistics

7.3.2.1Social desirability

Social desirability and self-reported measures of study habits within the Mathematics Support Centre (Actual, Aspirational and Estimated) were checked to ascertain if there were any correlations between the participants' self-reported time spent within the Mathematics Support Centre and socially desirable responding as indicated using the Marlowe Crowne measure of social desirability. Table 2 of Appendix 3.4.2 shows the Kendall's Tau Correlation coefficients of self-reported study habits scores with scores on the Marlowe Crown Social Desirability Scale. From the coefficients it is suggested that the effects of social desirability on the self-reported measures of study habits were not significant.

7.3.2.2 Personality, Mathematics Diagnostics and Study Habits Scores

Table 7.2 shows the mathematics and personality data obtained during the study. Participants who did not provide any Mathematics Support Centre usage data are included in the data presented in the table for completeness here.

Table 7.2: Mean Mathematics and personality scores across course groups

	All Courses	Sports Science	Social Work	Psychology
Maths Diagnostic (SD)	5.2 (2.23)	5.26 (2.0)	3.26 (1.67)	5.67 (2.15)
Median	5	5	11	6
	N = 245	*N* = 34	*N* = 42	*N* = 169
Psychoticism (SD)	7.07 (3.79)	7.23 (3.18)	6.7 (3.59)	7.14 (3.93)
Median	7	7	9	7
	N = 235	*N* = 22	*N* = 44	*N* = 169
Extraversion (SD)	16.23 (4.76)	18.82 (3.75)	15.50 (4.63)	16.09 (4.83)
Median	17	20	9	17
	N = 235	*N* = 22	*N* = 44	*N* = 169

The data from Table 7.2 suggest that there are large differences in the mean scores of students from different courses on the extraversion scale and mathematics scores. Scores on the psychoticism scale do not seem to vary significantly between students from different courses. From the data it is difficult to ascertain whether there is any difference in psychoticism scores, particularly with such large standard deviations and overlaps between the scores from the different subject groups. All data where psychoticism, extraversion and mathematics diagnostic scores were available were analysed (regardless of usage data being available for these participants) to explore difference between the student groups on these measures. Further analysis was conducted to ascertain whether there was a relationship between personality and mathematical ability. A Kruskal–Wallis test was conducted to assess whether the personality traits (psychoticism and extraversion) and mathematics diagnostics scores differed across subject groups. A significant difference between the groups was found on the mathematics diagnostic test, $H(2) = 40.183$, $p < 0.01$ and extraversion scores, $H(2) = 10.474$, $p < 0.01$. Post-hoc testing comprised three Mann-Whitney U tests to compare all the possible pairings of the subject groups. As three tests were performed, a Bonferroni correction was used such that significant effects occurred when $p < 0.017$ rather than $p < 0.05$. The results of these tests suggested that there was no significant difference between sports science and psychology students scores on the mathematics diagnostic test ($U = 2535$, $z = -1.092$, $p = 0.275$, $r = -0.077$). However, social work students scored significantly lower than both sports science students ($U = 312$, $z = -4.245$, $p < 0.0005$, $r = -0.49$) and psychology students ($U = 1357$, $z = -6.244$, $p < 0.0005$, $r = -0.43$) on the mathematics diagnostic test.

Further post-hoc tests were carried out on the extraversion scores, a Bonferroni correction was used again applied as three Mann-Whitney U tests were carried out. The results of these tests suggested that there was no significant difference between social work and psychology students' scores on the psychoticism scale (*U* = 3333, *z* = -1.059, *p* = 0.291, *r* = -0.073). However, sports science students scored significantly higher than both social work students (*U* = 254.5, *z* = -3.131, *p* = 0.001, *r* = -0.39) and psychology students (*U* = 1162, *z* = -2.866, *p* = 0.004, *r* = -0.201) on the psychoticism scale. To test the relationships between mathematics diagnostics performance, psychoticism and extraversion scores, Kendall's tau (two-tailed tests) correlation coefficients were examined. The results can be seen in Table 7.3 (below).

Table 7.3: Kendall's tau coefficients showing the correlations between personality variables and mathematics diagnostic scores

	N	Psychoticism	Extraversion
Sports Science	20	-0.183	-0.175
		p = 0.309	*p* = 0.338
Social Work	33	0.077	-0.131
		p = 0.565	*p* = 0.330
Psychology	151	-0.066	0.121
		p = 0.272	*p* = 0.043
All Courses	204	-0.059	0.064
		p = 0.256	*p* = 0.211

*significant at the *p* < 0.01 level

From Table 7.3 there do not appear to be any significant correlations between either psychoticism or extraversion and mathematics diagnostics scores. As eight correlation tests were carried out a more conservative alpha of 0.01 was used. These data do not support the prediction that there would be a negative correlation between psychoticism and mathematics diagnostics scores.

The data presented in Table 7.4 (below) suggest that there is very high variation in the actual, aspirational and estimated measures of usage that were obtained in the study. Large variations in the actual, aspirational and estimated measures of Mathematics Support Centre usage were also observed in the year long intervention study discussed in Chapter 6. Furthermore, the means and medians of the actual, aspirational and estimated number of hours of Mathematics Support Centre usage were lower in this study compare to those found in the previous study.

Of particular interest is the change in the number of hours that the Mathematics Support Centre was used; the greatest change was observed for those participants in the control group with aspirations of using the Mathematics Support Centre. The smallest changes were observed in students who did not have any aspirations to use the Mathematics Support Centre and were also in the control group. It should be noted here that students on all of the courses were expected to engage with mathematics to some extent as part of their course in the form of either statistics or research methods.

Table 7.4: Mean scores for Mathematics Diagnostics, personality and Usage across the four aspiration-based subgroups (SD in parentheses)

	Aspiration = 0 (Control) *N* = 24	Aspiration = 0 (Treatment) *N* = 23	Aspiration > 0 (Control) *N* = 56	Aspiration > 0 (Treatment) *N* = 65
Maths Diagnostic	5 (2.67)	5.22 (2)	6.18 (2.12)	5.31 (2.01)
Psychoticism	8.08 (4.41)	7.91 (3.68)	6.59 (3.27)	7.48 (4.60)
Extraversion	17.58 (5.02)	16.70 (4.27)	16.59 (4.52)	15.35 (5.61)
Actual*	0.33 (1.43)	0.0 (0.0)	1.45 (3.13)	2.85 (8.94)
Aspirational*	0.00 (0.00)	0.0 (0.0)	11.32 (11.65)	12.28 (14.33)
Estimated*	0.00 (0.00)	0.35 (1.67)	8.13 (11.23)	9.32 (11.98)
Actual**	1.13 (3.42)	1.83 (4.32)	4.04 (5.81)	6.25 (12)
Aspirational**	1.13 (7.35)	2.13 (4.13)	8.06 (7.91)	12.88 (15.37)
Estimated**	2.50 (6.00)	1.43 (3.58)	6.04 (6.43)	10.25 (15.37)
Actual (post) – Actual (int)	0.79 (3.2)	1.83 (4.32)	2.59 (6.26)	3.41 (8.9)

*measured at intervention, ** measured post intervention

7.3.3 Effectiveness of implementation intentions

To test the hypothesis that only participants who had constructed implementation intentions would show a significant increase in the time spent engaged with mathematical study, the actual times (after Aligned Rank Transforms had been performed) spent by students studying mathematics were subjected to a four-way analysis of covariance having two levels of Condition (control, treatment), two levels of Time (pre-intervention, post intervention), two levels of Aspiration at intervention (equal to zero, greater than zero) and three levels of psychoticism as measured using the EPQ-R instrument (low, medium, high). The scores on the Marlowe Crowne and Mathematics diagnostic instruments were used as covariates. All effects were judged to be statistically significant if they reached the 0.05 significance level. Participant psychoticism data was categorised into three levels, low (one or more standard deviation below the mean), high (one or more standard deviation above the mean) or medium (within one standard deviation of the mean). For completeness all of the main effects have been reported (Section 7.3.3.1) together with the relevant interactions with Time (Section 7.3.3.2) and psychoticism.

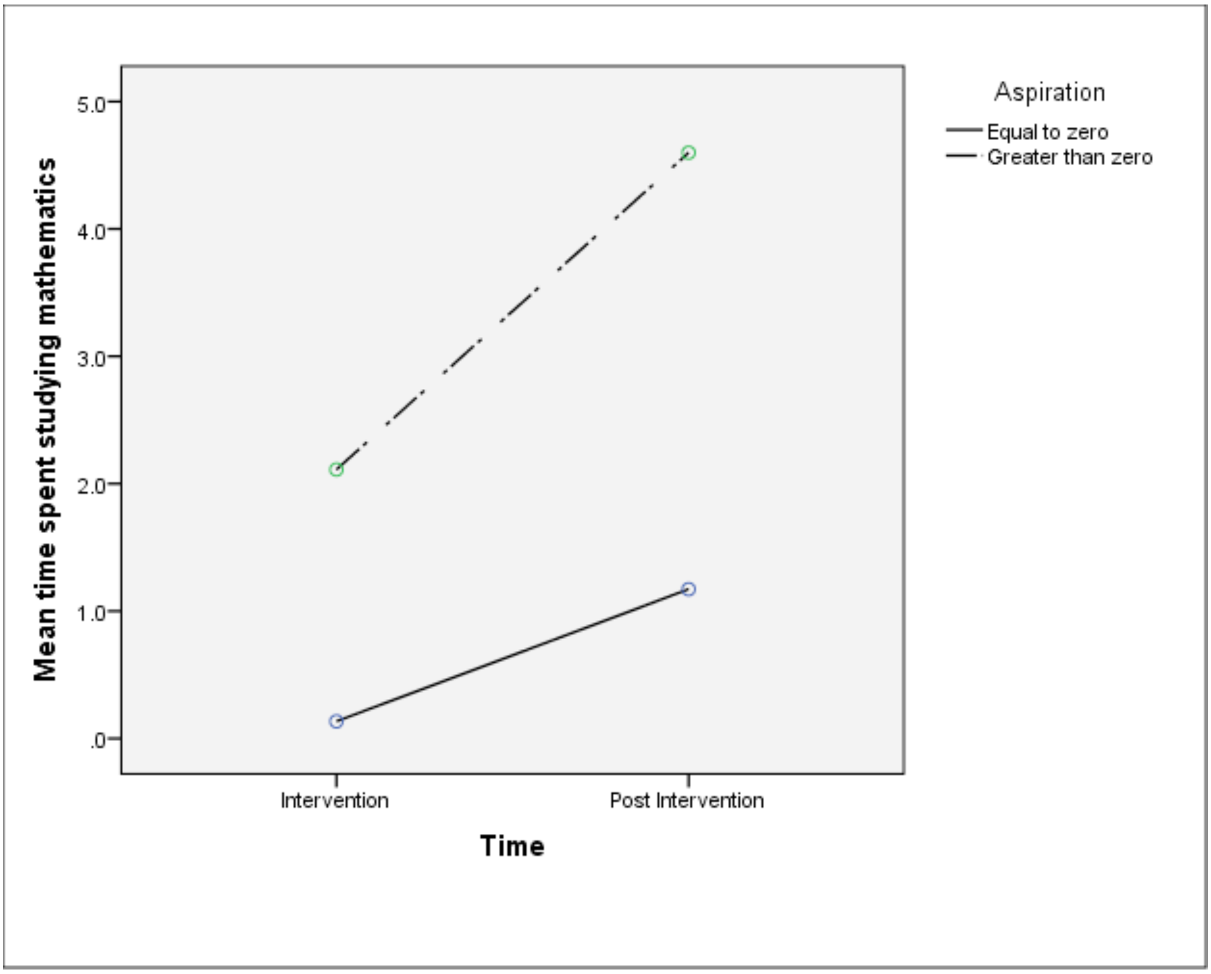
7.3.3.1 Main effects of Time, Condition, Aspiration and Psychoticism

The main effect of time was not significant, $F(1, 151) = 0.845$, $p > 0.05$. However, main effects were observed for aspiration, condition and psychoticism. There was a significant effect of aspiration on study time, $F(1, 151) = 7.960$, $p = 0.005$, indicating that those who had aspirations greater than zero ($M = 3.355$, $SE = 0.811$) spent significantly longer studying in the Mathematics Support Centre than those with aspirations equal to zero ($M = 0.653$, $SE = 1.076$) if the other factors were ignored. The main effect of condition was found to be significant, $F(1, 151) = 10.302$, $p = 0.002$, suggesting that those in the treatment condition ($M = 2.142$, $SE = 0.904$) had significantly higher study durations than those in the control condition ($M = 1.866$, $SE = 0.983$) if the other factors were ignored. The main effect of psychoticism was found to be significant, $F(2, 151) = 6.887$, $p = 0.001$, indicating that the level of study was significantly different between low, medium and high levels of psychoticism. Post hoc Mann-Whitney tests revealed that low scorers (*Mdn* = 0) studied significantly less than medium scorers (*Mdn* = 0.5) on the psychoticism scale (U = 1353.5, z = -1.938, p = 0.25, d = -0.319). No significant differences were found between high scorers on the psychoticism scale (*Mdn* = 0) and the low scorers (U = 339, z = -1.114, p = 0.129, d = -0.182) or the medium scorers (U = 1398.5, z = -0.259, p = 0.402, d = -0.042). However, it should be noted that the interactions with time that are reported next are of interest as they directly relate to the hypothesis being tested and examine the changes in study habits over time.

7.3.3.2Interaction effects of Condition and Aspiration with Time

To test the hypothesis that only participants who constructed implementation intentions would show a significant increase in the time spent engaged with mathematical study, the Time*Condition, Time*Aspiration and the Time*Condition*Aspiration interactions were examined. The Time*Condition interaction, $F(1, 151) = 2.470$, $p = 0.118$ was not statistically significant. This result suggests that there was no significant difference in the changes in the study habits between participants in the control and treatment conditions. There was a significant Time*Aspiration interaction, $F(1, 151) = 8.210$, $p = 0.005$. This effect suggests that the change in the amount of time spent engaged with mathematical study was different between those who had aspirations equal to zero hours and those who had aspirations to study more than zero hours during the coming month. The interaction is shown in Figure 7.1 below and suggests that those who had initial aspirations of engaging in mathematical study also showed the greatest increase in the time spent studying. Those who did not originally aspire to study mathematics showed the least improvement in study habits over the duration of the study.

Figure 7.1: Interaction plot showing the relationship between Aspirations and improvements in the amount of time spent studying mathematics in the Mathematics Support Centre



Post Hoc Wilcoxon Signed Rank tests were carried out and suggested that the difference in improvements in study habits was statistically significant for those who had initial aspirations equal to zero (Z = -2.439, p = 0.016, d = -0.761) and those with aspirations greater than zero (Z = -4.210, p = 0.000, d = -0.829). Post hoc Mann-Whitney tests revealed that those with aspirations greater than zero used the support services more than those with aspirations equal to zero at baseline (U = 2134, z = -3.458, p = 0.001, d = -0.554) and post intervention (U = 1920, z = -3.632, p = 0.000, d = -0.584). These results suggest that those with aspirations greater than zero at baseline showed the greatest overall usage and improvement in the time spent using the support services.

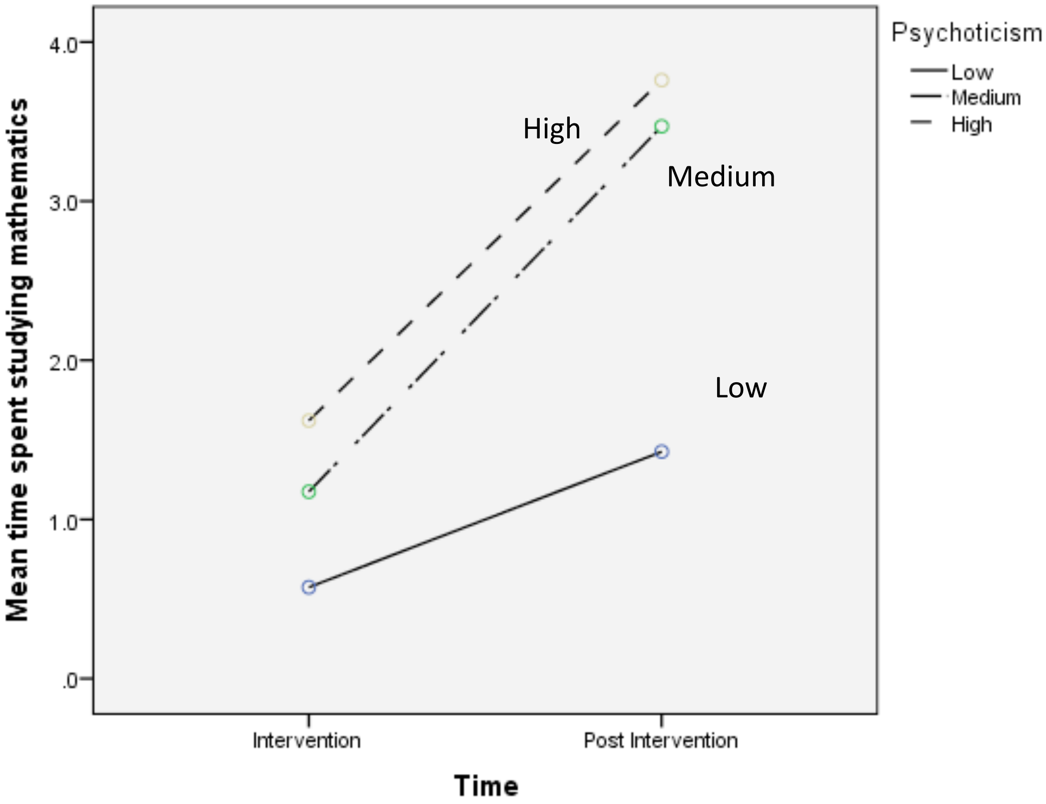
The Time*Condition*Aspiration interaction was not significant, $F(1,151)$ = 1.335, p = 0.250. This suggests that the interaction between Time*Aspiration was unaffected by the condition. Improvements in the amount of time spent studying were unaffected by whether participants belonged to the treatment or control conditions.

7.3.3.3Interaction effects of Time, Aspiration and Condition with Psychoticism

To test the hypothesis that changes in the time spent engaged with mathematical study would be negatively correlated with scores on the psychoticism scale and that psychoticism influences the effectiveness of implementation intentions on improving study habits; the Time*Psychoticism, Time*Aspiration*Psychoticism, Time*Condition*Psychoticism and Time*Aspiration*Condition*Psychoticism interactions were examined (the 4-Way interaction was found to be significant). Due to the overall sample size, the cell size for the 4-way interaction was low and resulted in reduced power. As a result of the small sample size, the results of the 4-way interaction analysis were likely to be spurious and misleading. For this reason the analysis and results of the 4-way interaction have been included in Appendix 3.4.3 rather than the main text.

The Time*Psychoticism interaction was found to be significant, $F(2,151) = 3.938$, $p = 0.022$. The interaction plot shown in Figure 7.2 (below) suggests that participants who scored low on the psychoticism scale showed little improvement in their study habits. Post hoc Wilcoxon Signed Ranks tests were carried out and suggested that the improvements in study habits were statistically significant ($p < 0.017$) for those who had medium ($Z = -4.052$, $p = 0.00$, $d = -0.833$) psychoticism scores, while those who had high ($Z = -1.693$, $p = 0.047$, $d = -0.704$) or low scores showed non-significant increases ($Z = -1.656$, $p = 0.054$, $d = -0.623$).

Figure 7.2: Interaction plot showing the relationship between psychoticism and improvements in the amount of time spent studying mathematics in the Mathematics Support Centre



The Time*Aspiration*Psychoticism interaction was not found to be significant, $F(2, 151) = 2.046$, $p = 0.133$; suggesting that the interaction shown in Figure 7.1 was consistent for all levels of psychoticism. The Time*Condition*Psychoticism interaction was found to be significant, $F(2, 151) = 4.561$, $p = 0.012$. Further analysis was carried out to examine the Time*Condition interaction at each level of psychoticism (low, medium and high). It was found that the Time*Condition interaction was statistically significant at low [$F(1, 25) = 4.430$, $p = 0.046$] and high

[$F(1, 20) = 14.633$, $p = 0.01$] levels of psychoticism. The interaction was found not to be significant for medium levels of psychoticism, $F(1, 102) = 2.965$, $p = 0.088$. Interaction plots (Figures 7.3, 7.4 and 7.5) are shown below to illustrate the Time*Condition*Psychoticism interaction further.

Figure 7.3: Interaction plot showing the relationship between Condition and improvements in the amount of time spent studying mathematics in the Mathematics Support Centre for those with low psychoticism scores

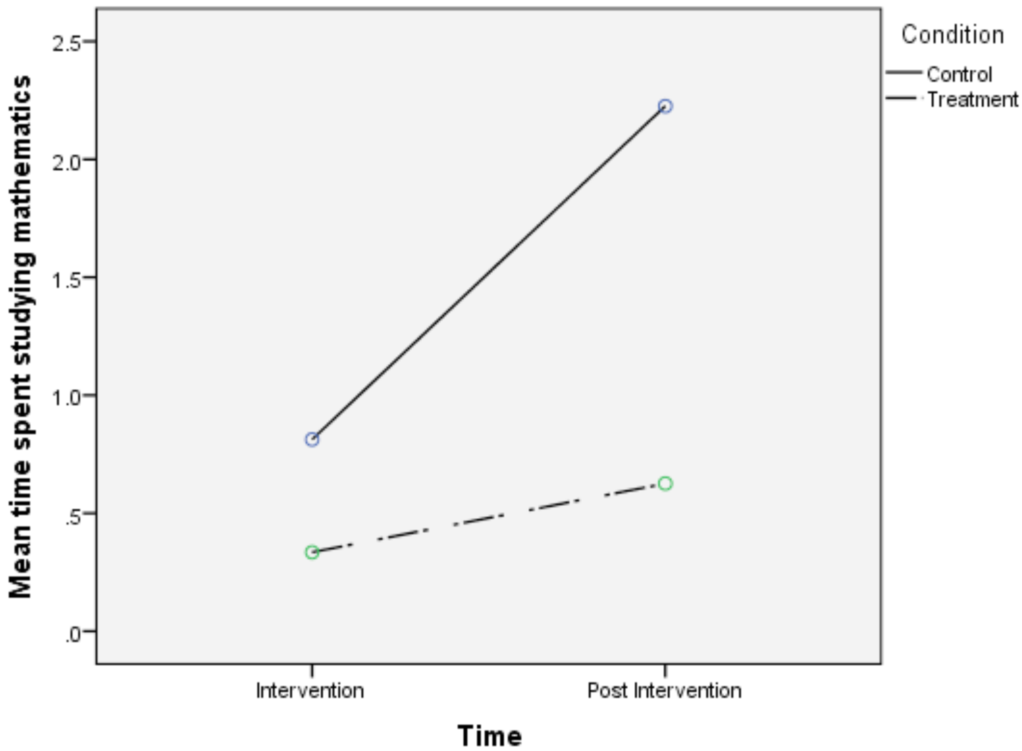


Figure 7.4: Interaction plot showing the relationship between Condition and improvements in the amount of time spent studying mathematics in the Mathematics Support Centre for those with medium psychoticism scores.

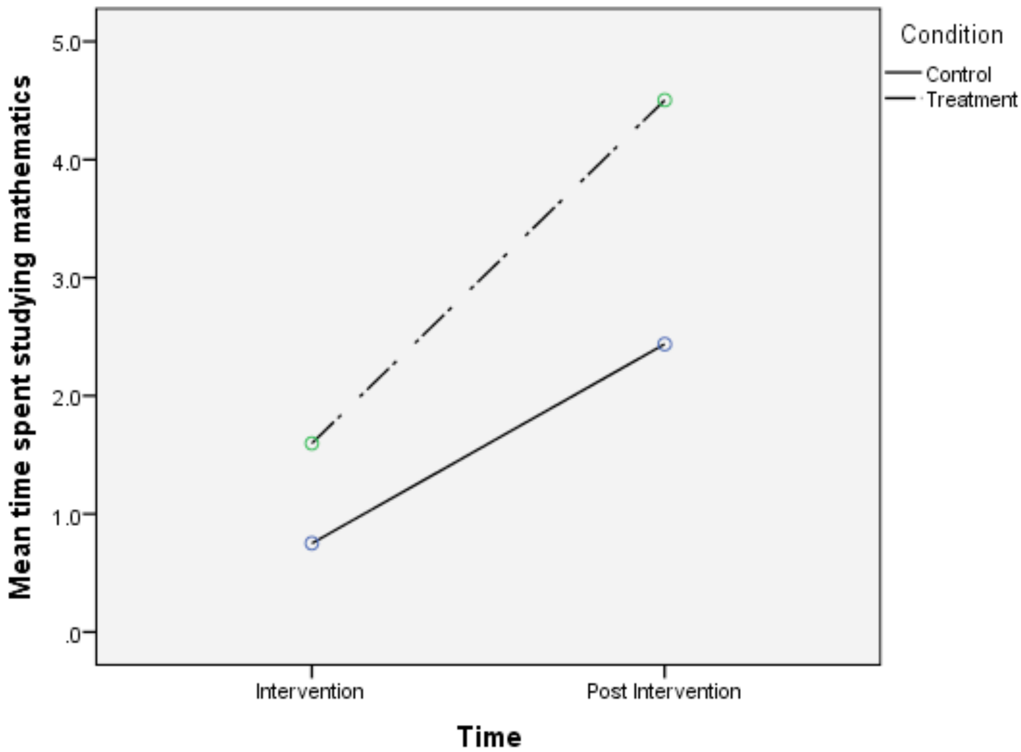
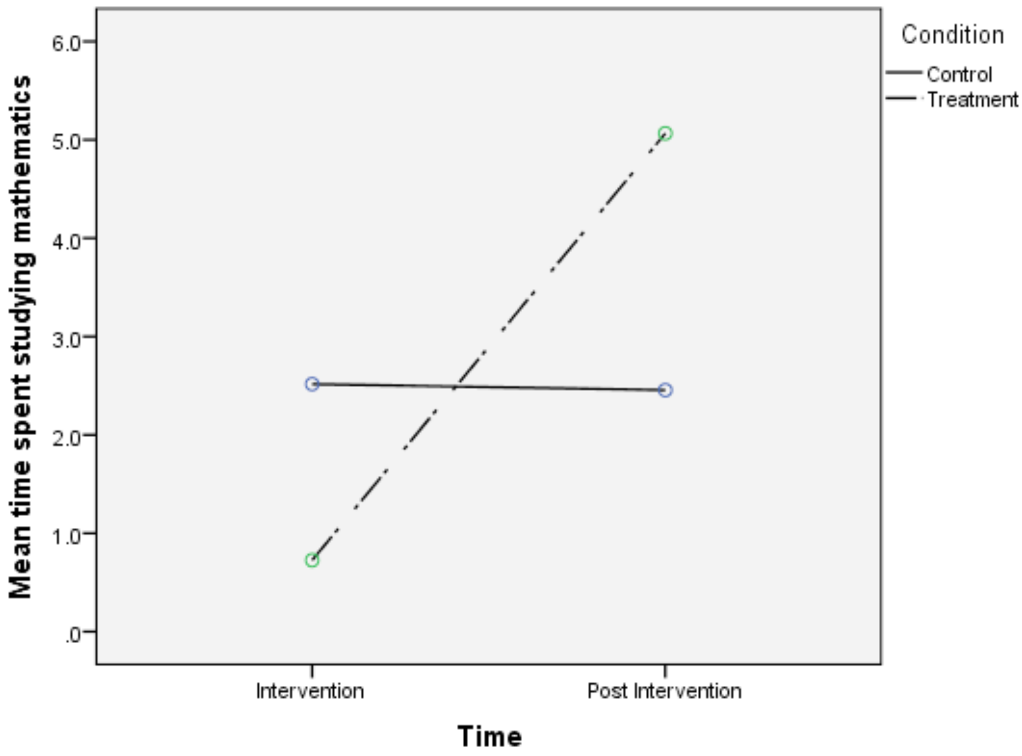


Figure 7.5: Interaction plot showing the relationship between Condition and improvements in the amount of time spent studying mathematics in the Mathematics Support Centre for those with high psychoticism scores.



Wilcoxon Signed Rank tests were used to ascertain if the changes in the use Mathematics Support Centre were statistically significant. Post hoc tests revealed that at low levels of psychoticism changes in usage were not statistically significant for those in the control group (z = -1.187, p = 0.281, d = -0.644). The changes in Mathematics Support Centre usage by those with high levels of psychoticism were also found to be not significant in the control (z = 0, p = 1.0, d = 0) or treatment condition (z = -1.970, p = 0.055, d = -1.088). However, significant increases in the time spent using the Mathematics Support Centre were observed for medium scorers on the psychoticism scale in both the control (z = -2.793, p = 0.004, d = 0.805) and treatment (z = -2.914, p = 0.003, d = 0.855) conditions.

7.3.4 Summary of Results

The main effects suggest that overall the participants who had aspirations greater than zero also had the greatest usage of the Mathematics Support Centre. Furthermore, all participants regardless of treatment condition showed a statistically significant increase in the time spent using the Mathematics Support Centre over the course of the intervention period.

The effect of the intervention (Section 7.3.3.2) on the amount of time students spent using the Mathematics Support Centre was tested by examining the interactions involving time (i.e. Time*Condition, Time*Aspiration and Time*Condition*Aspiration). The data suggest that participants who created implementation intentions did not increase their use of the Mathematics Support Centre compared to those who had not. However, the biggest improvements in support centre usage were by those who had originally intended to use the Mathematics Support Centre prior to the intervention.

The effect of psychoticism on the improvements in Mathematics Support centre was looked at in Section 7.3.3.3. The results suggested that only participants with medium scores on the psychoticism scale (both control and treatment conditions) showed statistically significant improvements in their usage of the Mathematics Support Centre.

7.4 Discussion

The literature suggested that the formation of implementation intentions could improve the likelihood of goal-related behaviours (Webb and Sheeran 2007, Gollwitzer 1999 and Casper 2008). Results from this study suggest that overall there was a statistically significant increase in the time spent using the Mathematics Support Centre regardless of treatment condition. Those who had Aspirations greater than zero generally had the greatest usage of the Mathematics Support Centre (before and after the intervention). The effectiveness of the intervention on increasing the amount of time students spent using the Mathematics Support Centre suggested that participants who created implementation intentions did not increase their use of the Mathematics Support Centre significantly more than those who had not. However, the biggest improvements in Mathematics Support Centre usage were by those who had originally intended to use the Mathematics Support Centre prior to the intervention; which highlights the need to raise awareness of the Mathematics Support Centres in the first place. The results suggested that only participants with medium scores on the psychoticism scale (both control and treatment conditions) showed statistically significant improvements in their usage of the Mathematics Support Centre.

Three main points were raised as a result of the study and will be discussed in detail in this section. Firstly the implementation intentions did not seem to work. Secondly, the aim of the intervention was to improve usage by students who may not have been aware of the services or had no intention to use the services. Data suggested that the greatest increases in usage were observed by those who intended to use the services regardless of the condition they had been allocated to. Thirdly, only participants with medium scores on the psychoticism scale showed improvements in the actual usage of the Mathematics Support Centre.

7.4.1 Why implementation intentions may not have worked

Looking at the control and treatment conditions, the results do not support the hypothesis that implementation intentions have a positive effect on the increase in usage of the Mathematics Support Centre. These results do not support past studies found in the literature on the effectiveness of implementation intentions (e.g. Webb, Christian and Armitage 2007). To understand why implementation intentions did not appear to work it is necessary to re-examine how implementation intentions are thought to work and compare this with the properties of behaviours where it has worked and also where it has not. Gollwitzer and Sheeran (2006) state that the formation of implementation intentions aids individuals in performing behaviours that can help in the achievement of an intended goal (goal intentions). It should be noted that the intended goal can be general in the areas of health behaviours these could be i.e. become fitter, quit smoking or always practice safe sex. In the area of education these goals could include becoming a better reader or improving mathematics ability. The implementation intentions themselves should always be specific and link a situational cue to a specific behaviour that when carried out brings an individual closer to achieving their desired goal intentions (e.g. I want to improve my level of mathematics). The formation of effective implementation intentions requires both suitable situational cues (e.g. when or where) together with an appropriate response behaviour that will help in reaching the intended goal. Furthermore, Gollwitzer (1999) suggests that the formation of implementation intentions moves control of the behaviour from the individual to the situational cue. It was also noted by Sheeran, Webb and Gollwitzer (2005) the effects of implementation intentions were greatest for individuals who have strong goal intentions. As mentioned in Chapter 2, health related goals tend to focus on complete adherence or cessation of an activity. Once the goal has been achieved, goal directed behaviours need to be maintained. An example of this includes increasing fitness where once the target weight or desired level of fitness has been achieved, the individual still needs to adhere to some form of fitness regime or diet. The same is true for sexual behaviours where once the goal of 'always having safe sex' has been achieved, it is necessary to maintain the behaviour. Implementation intentions used in this context have been effective in promoting behaviour change. However, the current study did not provide any evidence to suggest that implementation intentions are equally effective at initiating behaviour change in study behaviours, particularly the use of Mathematics Support Centres. The study described in this chapter deals with a behaviour that is quite different from health related behaviours in several aspects.

Students who have identified a need to improve their mathematical ability could use the Mathematics Support Centre on an ad hoc basis until they perceived that their ability was sufficient for the demands of the course they had enrolled on. Unlike a health related goal where individuals would need to maintain the behaviour, students may not feel compelled to continue using the Mathematics Support Centre once they have perceived their mathematical ability is sufficient for the requirements of their course of study. The behaviours related to Mathematics Support Centre usage are different from those of health behaviours and it is suggested that the perception of the need to use the support may interfere with the situation cue link. The implementation intention may thus only be effective while the individual perceives a need to use the Mathematics Support Centre. Furthermore, the evaluation of need may counter the effect of the implementation intention. The data collected was on the usage of the Mathematics Support Centre by students from courses that could be considered non-mathematical and that on entry the requirements are for a GCSE Mathematics qualification (Grade C or above). The majority of the students provided initial usage data that suggested they would not be engaged with mathematical study over the coming month. However, during the beginning of the year all students had been given information on the support available and also become more aware of the mathematical demands of the course they had enrolled on. It is also important to note that implementation intentions were created to improve the likelihood of performing behaviours in line with their intentions. In light of this it seems plausible that the statistically significant increases in study habits observed in both control and treatment conditions could be attributed to both having a very low measure of usage at baseline (they can only improve in most cases). A future study may look at the students' relationships with mathematics and self-evaluation of their own ability at frequent intervals during the study while also monitoring the use of the Mathematics Support Centre. Doing so may allow increases in usage to be matched with changes in perceived mathematical ability when implementation intentions are formed.

7.4.2 Intentions and actual usage of the Mathematics Support Centre

The literature suggested that weak students were less likely to make use of the support services despite having more reason to engage with the services on offer (Symmonds, Lawson and Robinson 2008 and Grehan et al. 2010). As such the aim of the intervention was to help students who did not ordinarily make use of the services (or may not have been aware of the services) and who may have had no wish to engage with the services on offer or who have lower mathematical attainment (measured using the mathematics diagnostic test). It was found that students who did not wish to use the services tended to have lower mean scores on the mathematics diagnostic test. This is supported by the literature that suggests that those who use the services were more able than those who did not engage with the services (e.g. Grehan et al. 2010). In the previous section it was stated that implementation intentions did not work. Furthermore, the data suggested that the biggest increases in usage of the Mathematics Support Centre were from those who had aspirations greater than zero (i.e. intentions to use the services) regardless of the treatment condition they had been allocated to. However, the differences in mathematical diagnostic scores between those who had aspirations to use the services and those who had not were statistically significant. In light of the intention seeming to be a better predictor of the usage of the support centre, it would seem sensible to suggest that it is important to raise the intention of individuals at the start of the academic year. Intentions could be raised by raising awareness of the services and also by increasing students ability to self evaluate their own mathematical ability. It may be prudent to screen students based on intentions, those with intentions make implementation intentions while those who do not are given some form of intervention that increases their intention to use the services through self evaluation or diagnostics of their own ability. This would be followed by support to form action plans and implementation intentions.

7.4.3 Personality and improvements in usage of the Mathematics Support Centre

Past literature suggested that personality could influence the effectiveness of implementation intentions (e.g. Webb, Christian and Armitage 2007). However, this study has suggested that the use of implementation intentions to improve the use of the support services by those students was ineffective. The results from the study discussed in this chapter suggested that only participants with medium levels of psychoticism showed significant improvements in the amount of time using the Mathematics Support Centre with no difference between control and treatment conditions. This result is only partially in line with the hypothesis that increases in the time spent engaged with mathematical study would be negatively correlated with scores on the psychoticism scale. This raises the question of why only those with medium scores on the psychoticism scale tended to increase the amount of time spent engaged with the Mathematics Support Centre. High scorers may have found it difficult to follow through with their personal study plans and or would have preferred to work more independently. However, those scoring lower on the psychoticism scale did not improve their usage. Low scorers were likely to be higher scorers on the conscientiousness scale. As such they would already be more likely to be able to work in groups, though not necessarily within the Mathematics Support Centre. With these students tending to be more conscientious they could have shown little improvement in the usage of the Mathematics Support Centre due to already having well established study habits at baseline that involved studying outside of the Mathematics Support Centre. However, it should be noted that the current study did not explore the other strategies that students could have used to improve their mathematical ability. It is possible that students may have improved their study habits using other strategies but these were not captured in the present study. The next section discusses a number of methodological issues that were raised during this study and attempts to describe how they could be minimised.

7.4.4 LIMITATIONS

It is important to try to ascertain why the implementation intentions did not appear to work in the context of mathematical study behaviours. Many students did not have an intention to use the services (as demonstrated by low aspirations) in the first place. Furthermore, the need to use the Mathematics Support Centre varied between students from different courses. The participants' intentions to improve their mathematical ability could also have been achieved through means other than the use of the Mathematics Support Centre. Changes in engagement with mathematical study outside of the Mathematics Support Centre would not have been captured using the self-report measures used in this study. It is suggested that one major area of concern that had a major influence on the ability to detect the effect of the implementation intentions was the small number of occurrences of the behaviour being measured. For example, the usage of the support centre is not a common activity for the majority of students even from mathematics courses (see Section 1.2.3). Measuring accurately the typical usage of a student over a short period of time becomes difficult if the number of occurrences is small combined with the inherent errors that come from self-report measures. This suggests that either the implementation intentions did work and were not detected or the implementation intentions did not work at all. It is acknowledged that methodologically there were a number of weaknesses that could be addressed in future research. The usage data were collected in the first term and as such students actual usage of the support centre was likely to have been low at baseline. However, this had inadvertently created a floor effect in that those who had low initial usage had a lower possible range of actual hours (if their usage decreased) than those who had higher initial usage. Collection of data in the first term also increased the likelihood that their reported usage of the Mathematics Support Centre was not representative of their typical usage later in the academic year. This was only problematic with data from first year students. At the beginning of the participants' undergraduate psychology studies in the first year it was likely that students were unaware of the difficulties relating to mathematics that could have potentially caused them problems. Many demands such as coursework, projects, and dissertations have yet to be started or even set by the lecturers. So usage of the Mathematics Support Centre would have been perceived as unnecessary. However, later in the year there may be bigger differences between students in their perceived need for the services as they become more aware of the course requirements. An improvement here would be to collect data at a time where students are more likely to be engaged with 'typical' usage, possibly during the second term or during the second year. The EPQ-R instrument measured both extraversion and psychoticism adequately for the purposes of the intervention study. However, the literature (Webb et al. 2007) suggests that conscientiousness may be a better predictor of the effectiveness of implementation intentions. A future study may look at using the NEO instrument to explicitly measure conscientiousness or explore the relationship between psychoticism and the individual facets of conscientiousness using factor analytic techniques.

The usage of the Mathematics Support Centre was based on a self-report instrument created for this study. However, as the instrument was reliant on the accuracy of the participants reports there was an element of uncertainty in the data. This uncertainty was not necessarily due to the participants lying but rather there being errors in their estimates for actual, aspirational and estimated study behaviour. For example, it is likely that there is less confidence in a participants estimate of 40 hours of actual use (if this was split into 1 or 2 hour visits) when compared to a participants who used the mathematics support services once for one hour over the past month. This could be remedied through a better method of collecting usage data. One strategy could be through the use of swipe card based systems and the use of appointment logging. However, this would also require that the operation of the Mathematics Support Centre be changed to some extent i.e. all users must be required to declare who they are by using identity cards as unique identifiers or by usage being limited to appointments with set durations. Doing this could allow the exact usage of the services by individuals to be more accurately measured (though this would also introduce ethical issues relating to the use of this information). At Coventry University the Mathematics Support Centre uses a voluntary swipe card based system where students are asked to swipe their card upon entry to the centre. Unfortunately this would also be prone to errors in acquiring the amount of usage. The system records the number of unique visits but cannot track the duration of the visit. It also relies on users swiping their card upon entry. A major issue with the data was the non-normality of the usage data, which resulted in the Aligned Rank

Transform method being used prior to a series of ANCOVA. The non-normally distributed residuals resulted in the inability to use multiple-regression techniques for identifying significant predictors in a linear model.

7.4.5 *IMPLICATIONS*

The implications for universities with regards to the use and uptake of Mathematics Support Centres are that the use of implementation intentions alone are unlikely to improve the usage of the support service amongst students who have no wish or aspiration to use the support services. This also suggests that other strategies would need to be used to encourage the use of the service by the weaker students who may not be currently using the services. Furthermore, the results suggested that increases in students' usage (as a whole) of Mathematics Support Centres are likely to be the same regardless of whether or not the students form implementation intentions. The data suggested, those whose intentions to study were zero, showed lower changes in their engagement with the mathematics support services. Based on the above the following suggestions may increase the likelihood of improving student engagement with mathematics support provision within a higher education context.

- Students need to be made aware not only of the support provision that is available but also that the student may benefit or need to use the service.
- Changing the student's perception of both their own ability in relation to what the university expects and also the perception of the suitability of

university provision for their particular needs.

Future research should aim to look in more detail at the role of implementation intentions in changing behaviour paying particular attention to the interactions that may exist with different personality traits. Furthermore, there is a need to design a measure of the study behaviours that results in a distribution that is closer to normal so as to facilitate the use of parametric methods and also allow for the examination of interaction effects between multiple variables. To improve the analysis of the data a better technique would need to be developed that can cope with data that is both severely skewed and consists of a large number of data items equal to zero. Empirical evidence presented in the literature (e.g. Casper 2008, Luszczynska 2006 and van Hooft et al. 2005) suggests that using implementation intentions are highly effective in assisting individuals to perform goal directed behaviours. Importantly, future research needs to address the question of why implementation intentions seem to be ineffective in the educational context described in this intervention study.

Chapter 8 Discussion

This chapter aims to bring together the results of the two studies that were described in Chapters 5, 6 and 7. The main focus of this chapter is to discuss the findings of the studies in relation to key theories of behaviour change and relate them to the initial problem of student engagement with mathematics support services in Higher Education Institutions. Furthermore, this chapter will also examine the methodological and analytical issues related to the data gathering and analysis involved during the three studies. Conclusions and ideas for future research will also be discussed by drawing on the results of these studies and the limitations that were identified. The general findings of this research are that implementation intentions were ineffective in improving study behaviours and the usage of Mathematics Support Centre type services. However, this raises the question of why did these interventions appeared not to work in the educational context that they were used in within the studies even though the literature suggests otherwise.

8.1 Why the research was carried out

Earlier in Chapter 1 it was highlighted that research evidence suggests that there has been a decline in the mathematical abilities of students entering university since the 1980s (Mulhern and Wylie 2004, Greer and Semrau 1984, Kounine, Marks and Truss 2008: 8-12). The decline in abilities has led to a mismatch between the mathematical skills required for university courses and the abilities of students entering into university education. A number of strategies have been employed by Higher Education Institutions to address the problem of mathematical attainment particularly in the case of students whose abilities put them at risk of failing their chosen course of study. One of the numerous strategies involved to assist undergraduate students improve their mathematical skills is the Mathematics Support Centre. Services such as these provide students with the opportunity to discuss and obtain support with areas of mathematics that they find problematic. The services are often of the drop-in, by appointment or vocation specific taught class type. Many of the centres provide a mixture of these services, in some institutions the mathematics support provision is combined with literacy support (e.g. the Centre for Learning Support and Development at London South Bank University). Evaluations of the provision by service providers have suggested that use of Mathematics Support Centre services is related to improved mathematics performance (Lawson, Croft and Halpin 2001; Gill and O'Donoghue 2007). Users of the service have also commented on the usefulness and friendliness of the services on offer (Bhakta, Lawson and Goodband 2007). However, the benefits of these improved services were only evident in the cases where students had engaged with the services on offer (Lawson *et al*. 2001: 15-17). The literature has suggested that engagement with the support services was more of a problem for weaker students than it was for more able students (Symmonds, Lawson and Robinson 2008). The research in this thesis has therefore tried to address the problem of engagement through the use of an intervention aimed at promoting the use of mathematics support services amongst students from disciplines that do not require knowledge of mathematics beyond GCSE standard on entry. In order to promote increased usage among students an intervention based on implementation intentions was used. Past literature has suggested that interventions based on this theory could prove effective in facilitating goal directed behaviours (Gollwitzer 1999, Webb and Sheeran 2007, Luszczynska 2006). However, this intervention strategy has not been used in the context of promoting self-directed study through the use of Mathematics Support Centres. The studies in this thesis explored and discussed the effectiveness of the use of implementation intentions within the context of non-compulsory mathematics learning in particular the use of Mathematics Support Services. The role of personality on the effectiveness of implementation intentions used in the context of study behaviours was also examined.

8.2 AN EXPLANATION OF THE RESULTS

The studies that have been carried out as part of this thesis have aimed to explore the effectiveness of implementation intentions as a tool for improving the use of Mathematics Support Centres and informal mathematical study outside compulsory lectures and workshops. The Term Long Study (Chapter 7) looked at the use of the Mathematics Support Centre while The Year Long Study (Chapters 5 and 6) looked at general mathematics study habits.

8.2.1 DO IMPLEMENTATION INTENTIONS INCREASE THE USAGE OF MATHEMATICS SUPPORT CENTRES?

Data from the Year Long Intervention Study (Chapter 6) suggested that those students who formed implementation intentions engaged with more mathematical study after the intervention whereas those in the control condition did not show a significant improvement over the course of an academic year. However, the differences in the pre and post intervention measures of the actual time spent engaged with mathematical study were not significantly different between control and treatment groups (possibly because of the small sample sizes). The results of the Term Long Intervention Study (Chapter 7) also suggest that the formation of implementation intentions did not result in improved usage of the Mathematics Support Centre over the course of an academic term. The Term Long Intervention Study also suggests that participants who had aspirations of using the services used the services more than those who did not aspire to use the services, both before and after the intervention was administered. However, those who did not indicate any aspiration (i.e. intention) to use the services also showed a significant improvement in the amount of time spent engaged with mathematical study (though their usage of the Mathematics Support Centre was still less than those who had originally intended to use the services). There was no significant difference between the improvements in actual usage between the control and the treatment group. In light of the results from both of the intervention studies, there seems little evidence to suggest that implementation intentions as used in this thesis have an effect on improving the use of Mathematics Support Centres by undergraduate students.

Although meta-analyses (Gollwitzer and Sheeran 2006) support the idea that the formation of implementation intentions are beneficial in facilitating goal directed behaviours, the analysis of data from both the Year Long and Term Long intervention studies suggests that implementation intentions may not have an effect on the amount of time undergraduate students spend engaged with mathematical study. This section aims to explain why both of the studies discussed in Chapters 6 and 7 suggested that implementation intentions did not work in the context of Mathematics Support Centre. Based on the studies described in this thesis, evidence was found to suggest that intended study habits were higher than actual study habits. This was expected and was in line with past research (e.g. Kirner at al. 2006, Tudor et al. 2007).

In Chapter 7 the reasons why implementation intentions may not have worked were discussed. It was suggested that behaviours involving the use of Mathematics Support Centres are generally different from those where implementation intentions have been used in the past (e.g. health interventions). Unlike health related goals where individuals would need to maintain the behaviour, students may not feel compelled to continue using the Mathematics Support Centre once they have perceived their mathematical ability is sufficient for the requirements of their course of study. It is suggested that the perception of the need to use the support may interfere with the situation cue link. Implementation intentions have been shown to both facilitate the performance of behaviours that help reach a desired goal and also to shield the goal striving behaviour from detrimental thoughts or attitudes (Achtziger, Gollwitzer and Sheeran 2008). The self-evaluation of students own mathematical ability may result in students feeling that they do not need to use the Mathematics Support Centre. It is possible that implementation intentions as they were used in this study were not effective against shielding the individual from feelings that the service was no longer useful. This would seem sensible from the students' point of view as they may perceive the goal of adequate mathematical ability had already been achieved. The implementation intention may thus only be effective while the individual perceives a need to use the Mathematics Support Centre. Furthermore, the evaluation of need may counter the effect of the implementation intention. The data collected was on the usage of the Mathematics Support Centre by students from courses that could be considered non-mathematical and that on entry the requirements are for a GCSE Mathematics qualification (Grade C or above). The majority of the students provided initial usage data that suggested they would not be engaged with mathematical study over the coming month. However, during the beginning of the year all students had been given information on the support available and also become more aware of the mathematical demands of the course they had enrolled on. In light of this it seems plausible that the statistically significant increases in study habits observed in both control and treatment conditions could be attributed to both having a very low measure of usage at baseline (they can only improve in most cases). A future study should look at the students' relationships with mathematics and self-evaluation of their own ability at frequent intervals during the study while also monitoring the use of the Mathematics Support Centre. Doing so may allow increases in usage to be matched with changes in perceived mathematical ability when implementation intentions are formed.

The data from the Term Long Intervention Study (Chapter 7) suggested that those who had Aspirations greater than zero generally had the greatest usage of the Mathematics Support Centre (before and after the intervention). In light of this it seems sensible to consider that aspirations (i.e. intentions) are still very important in the prediction of Mathematics Support Centre usage. The literature suggested that weak students were less likely to make use of the support services despite having more reason to engage with the services on offer (Symmonds, Lawson and Robinson 2008 and Grehan et al. 2010). As such the aim of the intervention was to help students who did not ordinarily make use of the services (or may not have been aware of the services) and who may have had no wish to engage with the services on offer or who have lower mathematical attainment (measured using the mathematics diagnostic test). It was found that students who did not wish to use the services tended to have a lower mean score on the mathematics diagnostic test. This is supported by the literature that suggests that those who use the services were more able than those who did not engage with the services (e.g. Grehan et al. 2010). In the previous section it was stated that implementation intentions did not work. Furthermore, the data suggested that the biggest increases in usage of the

Mathematics Support Centre were from those who had aspirations greater than zero (i.e. intentions to use the services) regardless of the treatment condition they had been allocated to. However, the differences in mathematical diagnostic scores between those who had aspirations to use the services and those who had not were statistically significant. In light of the intention seeming to be a better predictor of the usage of the support centre, it would seem sensible to suggest that it is important to raise the intention of individuals at the start of the academic year. Intentions could be raised by raising awareness of the services and also by increasing students' ability to self evaluate their own mathematical ability. Past research has identified the lack of awareness as a contributing factor to low usage of Mathematics Support Centres (Symmonds, Lawson and Robinson 2008). It may be prudent to screen students based on intentions, those with intentions to use the support services would make implementation intentions while those who do not are given some form of intervention that increases their intention to use the services through self evaluation or diagnostics of their own ability. This would be followed by support to form action plans and implementation intentions.

8.2.2 Does personality or mathematical ability influence the effectiveness of the implementation intentions?

Analysis of the data from the Year Long Intervention Study suggested a negative correlation between psychoticism and actual time spent engaged with mathematical study in the treatment group only. However, the analysis of data from the Term Long Intervention Study found that only participants with medium (within one standard deviation of the mean) scores on the psychoticism scale (treatment and control) showed statistically significant improvements in their usage of the Mathematics Support Centre. Both the Term Long and Year Long Intervention Studies suggest that the intervention had no effect on the usage of the Mathematics Support Centre. The inconsistent results from the two studies suggest that psychoticism could be moderating the effectiveness of implementation intentions (Year Long Intervention Study) as well as the overall increase in the time spent using the Mathematics Support Centre (Term Long Intervention Study). However, conclusions based on the Year Long Intervention Study should be viewed with caution due to the small sample size and the differences in study habits observed at baseline.

As was highlighted by Lodhi, Deo and Belhekar (2002), a negative correlation may exist between the scales of conscientiousness and psychoticism. The negative correlation between psychoticism and increase in usage found in the data of the Year Long Study (Chapter 6) tends to support past research by Webb, Christian and Armitage (2007) who found that those scoring lower on the conscientiousness scale had a lower classroom attendance in both control and treatment conditions. Those scoring lower on the conscientiousness scale also showed the greatest improvement in attendance. However, the subsequent Term Long Study did not show any relationship between psychoticism and changes in study habits. The discrepancy between the two studies could be explained by the variation in participants between the two studies. The Year Long Study included students who were studying Business while the Term Long Study did not. Furthermore, the second study also included students who studied Social Work. Due to the small sample size (Treatment condition consisted of 16 participants) in the Year Long Intervention Study, it was not possible to carry out the analysis separately for each course being studied. If it had been possible to carry out this analysis then it might have been possible to ascertain if the negative correlation was due to the data from the Business students.

The results of the Term Long Intervention Study suggested that personality had an influence on the improvements in usage of the Mathematics Support Centre even though implementation intentions were not effective. Past literature suggested that personality could influence the effectiveness of implementation intentions (e.g. Webb, Christian and Armitage 2007). However, this study has suggested that the use of implementation intentions to improve the use of the support services by those students was ineffective. The results from the study discussed in this chapter suggested that only participants with medium levels of psychoticism showed significant improvements in the amount of time using the Mathematics Support Centre with no difference between control and treatment conditions. This result is only partially in line with the hypothesis that increases in the time spent engaged with mathematical study would be negatively correlated with scores on the psychoticism scale. This raises the question of why only those with medium scores on the psychoticism scale tended to increase the amount of time spent engaged with the Mathematics Support Centre. High scorers may have found it difficult to follow through with their personal study plans or would have preferred to work more independently. However, those scoring lower on the psychoticism scale did not improve their usage. Low scorers were likely to be higher scorers on the conscientiousness scale. As such they would already be more likely to be able to work in groups, though not necessarily within the Mathematics Support Centre. With these students tending to be more conscientious they could have shown little improvement in the usage of the Mathematics Support Centre due to already having well established study habits at baseline. However, it should be noted that the current study did not explore the other strategies that students could have used to improve their mathematical ability. It is possible that students may have improved their study habits using other strategies but these were not captured in the present study.

8.2.3 Are there differences between personality and mathematical ability between students from different courses?

Both the Term long (Chapter 6) and Year Long Intervention (Chapter 7) Studies suggested that there was a difference in both mathematical ability between students from different courses even though the mathematical requirements of students on entry to those courses were identical (GCSE or equivalent in mathematics). In both of the studies there was no significant difference between mathematics diagnostic scores for Psychology and Sports Science students. However, these two groups scored higher than students from other courses. The term long study showed that Social Work students were scoring lower on the mathematics test than those from

Psychology and Sports Science courses. While the Year Long Study showed that Psychology, Sports Science and Adult Nursing students scored higher on the test than Business students. psychoticism scores were also different between the groups in both of the studies. The level of mathematics within various courses as perceived by students could have influenced their course choice. Students have been found to choose courses so as to avoid mathematics in their post 16 education (The Royal Society 2008).

The difference in the psychoticism scores could be explained by the influence of personality on career choice (Garcia-Sedeño, Navarro and Menacho 2009). However, their research focused on differences between science and social science careers and not explicitly on social science careers or university course choices. It is suggested that though the personality trait of psychoticism was shown to be different between students from different courses in both of the studies; scores on the psychoticism scale alone were too crude a measure to fully explain the variance in course choice. Another difference could be in the types of student that are drawn to particular courses. Again it is suggested that though these differences may exist and be measurable using personality inventories, the use of a single measure as in this study was not adequate. The correlations between mathematics scores and the psychoticism scores is discussed in the next section.

8.2.4 *Is there a relationship between personality and mathematical ability?*

In Section 8.2.3 the differences in psychoticism and mathematics scores between the course groups was discussed. However, in addition to this statistically significant weak negative correlations were observed between psychoticism and mathematical ability in the Year Long Intervention data. Looking at data from both of the studies (across subject groups and combined), correlations from a number of course groups were either not significant or were positive.

This would suggest that it was difficult to generalise the relationships observed in any one group to other groups. Where there was a relationship, students from those groups could be supported and encouraged to develop their group working skills. Students who did have higher scores on the psychoticism scale may have also had greater difficulty in addressing their mathematical problems due to lower levels of organisation, planning and sticking to personal study goals (again suggested by higher scores on the scale). However, the correlation was weak and as such suggests that there are most likely other factors that contribute to low attainment that were not examined. Analysis of data from the term long intervention study suggested that there was no relationship between psychoticism and mathematical ability while extraversion was correlated with mathematical ability for students who had no aspiration of using the support services. The combined results of both studies suggest that the correlation between personality measures used in these studies and mathematical ability is unpredictable in both direction and statistical significance.

The Term Long Intervention Study (Chapter 7) suggested that no correlation exists. For the Year Long Intervention Study (Chapter 5), a significant positive correlation was found for Business Management students and a significant negative correlation was found amongst the Psychology students only. This seems to go against the literature, which suggests that this correlation should have been observed to some degree within all groups that were assessed. A study by Manzurul, Rabman and Mahmud (1986) found that academic achievement correlated negatively with the EPQ-R measure of psychoticism. Eysenck and Eysenck (1976) also argued that educational achievement and psychoticism should be negatively correlated with each other. A study by Chamorro-Premuzic and Furnham (2003) found that the academic performance of 75 British university students were associated with the EPQ-R personality measures of psychoticism, extraversion and neuroticism. Of these three variables they observed a negative association between psychoticism and academic performance. A negative relationship between psychoticism and academic achievement could be explained by the requirements of academic study. Academic study tends to involve organization, planning, strategies for prioritizing tasks, working effectively in groups and individually and increased initiative. High scorers on psychoticism were considered to be less able to fit in and work with others (Section 4.4.3). The negative correlation between psychoticism and conscientiousness also suggests that high scorers on the psychoticism scale are less likely to be able to follow through with their strategies for study and adhere to any study schedule they may have created; consequently they are less likely to be able to engage with independent study and comply with deadlines. The results of these digressions are likely to manifest as observed reductions in academic performance. The results of the tests carried out to examine the influencing factors of study habits using the measures of mathematical ability and personality need to be treated with caution. It is likely that the amount of mathematics that the different groups were required to engage with was significantly different at the time the study behaviours questionnaire was administered. Unlike the mathematics and personality questionnaires, the study behaviour data were collected later on during the academic year. It is also possible that the students improved their mathematical skills between taking the mathematics diagnostic test and the time when pre-intervention data on study habits were collected. The negative correlations between maths diagnostics scores and actual study observed in the Business Foundation Year group was explained by the students on that course being required to undertake a numeracy and mathematics diagnostic test as part of their course of study. However, given that data on the mathematical demands of students leading up to the pre-intervention data on study habits collection instrument is not available, it does not appear possible to meaningfully interrogate the data further without making assumptions that could be inherently incorrect or flawed.

Before trying to explain the inconsistencies in the observed correlations, the definition of psychoticism will be recapped. Psychoticism as described by Eysenck and Eysenck (1991: 6) suggests that a high scorer may exhibit antisocial tendencies, including an inability to form meaningful relationships with those around the individual. However, they also state that the instrument is designed to measure the tendency of the general population to exhibit psychotic tendencies. As such, it is only applicable in cases where the behaviours are non-pathological (as is assumed of the participants in the reported study). Within this study psychoticism does not primarily refer to the anti-social tendencies of the participants as suggested by Eysenck and Eysenck (1991) but rather to academic and study-related dispositions and tendencies. To clarify this, psychoticism can be thought of as being a combination of scales i.e. conscientiousness and agreeableness and openness (Matthews et al. 2003: 21-36). A study conducted by Lodhi, Deo and Belhekar (2002) involving 300 undergraduate students at a university in India explored the relationship between the big five factors as measured by NEO-FFI and the three factors of EPQ-R; it was found that there were significant correlations between psychoticism and both agreeableness (r = -0.42, $p < 0.001$) and conscientiousness (r = -0.33, $p < 0.001$). Significant correlations were also found by Lodhi, Deo and Belhekar between lie and both agreeableness (r = 0.51, $p < 0.001$) and conscientiousness (r = 0.46, $p < 0.001$). Their study also found very small but significant correlations between psychoticism and openness. It is thus assumed, based on the evidence in the literature, that psychoticism is negatively correlated with both agreeableness and conscientiousness. Agreeableness scales measure how individuals interact with those around them, in particular trust, straightforwardness, altruism, compliance, modesty, and tender-mindedness (Costa and McCrae 1992). The agreeableness scale suggests that high scoring individuals could be more able to use peer-to-peer and group study strategies. Conscientiousness however is of more interest as it relates more directly with an individual's personal study behaviours, beliefs and possibly academic achievement. High scorers on the conscientious scale tend to be more meticulous, organised, better at planning and also more able to self motivate towards a goal. The literature described earlier in this chapter suggests that conscientiousness is positively correlated with academic achievement suggesting that high scorers on the conscientiousness scale are more likely to score higher in intelligence tests than those who score lower on the conscientiousness scale. In light of this and the contributions of Matthews et al. (2003) and Lodhi, Deo and Belhekar (2002), it would be expected that participants who scored lower on the psychoticism scale would score higher on a test of ability (such as the mathematical diagnostic test as used in this study). However, as reported; correlations were only found within some groups of students (see Table 5.7). Those groups scoring lower on the psychoticism scale scored higher on the mathematics diagnostic test than higher scoring groups, which to some extent would support the literature on the relationship between psychoticism and academic achievement. At this point it should be noted that within both of the studies that were described in this thesis there were inconsistencies in the correlations observed across groups and across studies that do not appear to be in line with the literature. Combining data from all of the students would have suggested that a negative correlation should have been observed. This was not the case and an analysis of the data across subject groups tended to give either an inconsistent result or suggested no correlation existed. As was highlighted in the earlier section personality may influence course choice while mathematics avoidance may deter students from certain courses. Consequently it is reasonable to suggest that if the courses were composed of students determined by perception of mathematical requirements of the course, perception of their own mathematical ability and personality; combining all of the data may give a misleading result for an overall correlation between mathematical ability and psychoticism. The analysis carried out by subject would seem more sensible and less prone to misrepresenting any possible correlations.

The literature suggests that the relationship between extraversion and achievement is harder to identify. Allik and Realo (1997) for example found no significant correlation between extraversion and intelligence tests, only finding correlations with language related tasks. Furthermore, research by Martin et al (2006) (using scales for ambition and sociability that could be considered proxies for extraversion) suggests that extraversion is correlated with achievement. The analysis in this thesis supports the reviewed literature as there was not enough evidence to suggest any significant correlation between extraversion and mathematics achievement.

These results can be used to provide information about the types of learners who were involved in the study, in particular those who scored lower on the mathematics diagnostic test and higher on the psychoticism scale. As was discussed earlier, the literature suggests that there is a weak negative correlation between conscientiousness and psychoticism. It is suggested that those who tended to score higher on the psychoticism scale were more inclined to work individually, less able to work in groups and find it harder to follow through with personal study intentions and schedules. Learning through group work, collaboration and the formation of communities of learning have been shown to be important in the learning process e.g. Social Constructivism (Vygotsky 1978) and Communities of Practice (Lave and Wenger 1991, Wenger 1998). Furthermore, the ability to adhere with personal study intentions and schedules is important in allowing students to undertake effective private study, not just of mathematics but with their whole course of study.

It is beyond the scope of this thesis to ascertain if either psychoticism or extraversion can be used as predictors for mathematical ability either within or across disciplines. However, the data do suggest that students from different disciplines would appear to have significantly different psychoticism scores and mathematics scores, with those groups who scored higher on the psychoticism scale tending to have lower mathematics scores (e.g. Business students). Importantly, it should be noted that these conclusions are based on the assumption that a mathematical test is an acceptable proxy for mathematical aptitude. As this cannot be taken as fact, the maths diagnostic test is only taken as a proxy that indicates how well a student would perform when taking a mathematical test as part of their course and to some small extent their knowledge. However, undertaking tests and assessment is an important part of an individual's university study and as such the diagnostic test can still be thought of as a useful tool for predicting performance under similar conditions. If the results from this study were to be generalised to students from other disciplines then there are implications for how students from different subjects are assisted in not only developing their mathematical abilities and examination technique, but also on the effectiveness and value that the assistance would provide. An additional instrument to measure perceived ability could be used in place of the mathematics diagnostic test to measure attitudes and beliefs relating to the participants' relationship with mathematics; in particular confidence, comparison with peers and perceived academic needs as this would have been a better indicator of motivation than actual ability.

8.3 What do these results mean?

The main aim of this research was to add to the body of literature that has identified the mathematics problem and strategies on how it could be addressed. One of the strategies employed by a growing number of institutions of Higher Education is the Mathematics Support Centre. This thesis aimed to explore the use of implementation intentions as a means to increase the use of Mathematics Support Centres. The literature (see Section 8.1 and Chapter 1) has suggested that the usage of services similar to the Mathematics Support Centres could improve the mathematical ability of undergraduate students across a range of disciplines. Furthermore, the services also aim to reduce the number of students who drop out of university or fail their course due to not being able to cope with the mathematical demands of their chosen course.

This study aimed to use implementation intentions as a means to increase the amount of time students engaged with the Mathematics Support Centre at Coventry University. Historical Mathematics Support Centre usage data (refer to Table 1.1) from Coventry University suggests that 88.7% of students were from the Faculty of Engineering and Computing, 0.7% of the usage was known to be from students from the Faculty of Health and Life Sciences. The students being targeted by this intervention were primarily those from courses where a GCSE (Grade C) in mathematics was adequate for entry onto the course within the Faculty of Health and Life Sciences. Students were also recruited from Business Studies courses.

8.3.1 The Outcomes of the study

This section aims to briefly summarise the results of the study. After carrying out the studies discussed in Chapters 4, 5 and 6 the collected data suggested the following:

1. The formation of implementation intentions did not improve the usage of the Mathematics Support Centre significantly more than those who had not – Term long and Year Long Studies (if limited sample considered)

2. Students who had aspirations to use the Mathematics Support Centre used the service significantly more than those who had not, regardless of the intervention. – Term Long Study

3. Students from both conditions (treatment and control) improved their use of the Mathematics Support Centre. – Term Long Study

4. General Mathematical Study did increase for those in the treatment condition (however, variations at baseline and small sample size make the interpretation of the result difficult). – Year Long Study

5. Limited evidence to suggest that psychoticism is negatively correlated with increases in the time spent engaged with mathematical study for those who had formed implementation intentions. – Year Long Study. Though the Term Long Study suggests that greatest increases in usage of the Mathematics Support Centre were from those with medium psychoticism scores.

At this point the outcomes will be related to the initial problem of increasing student use of the Mathematics Support Centre in order to increase mathematical ability and consequently reduce the number of students failing courses due to being mathematically ill prepared.

8.3.2 Implications for implementation intentions

It should be noted that any increases in the study habits over time could have been the result of general maturation of the participants through increased familiarity with the course requirements, knowledge of the support on offer. The main outcome was that the implementation intentions were ineffective when used to increase the number of hours students engaged with mathematical study in the Mathematics Support Centre. Furthermore, the analysis of the data suggested that aspirations (i.e. intentions to study) were the greatest predictor of usage of the Mathematics Support Centre. It was found that those with intentions to use the support services used them more than those who did not regardless of the condition they had been allocated to. The literature has suggested that implementation intentions can shield an individual from negative thoughts feelings and attitudes (Achtziger, Gollwitzer and Sheeran 2008) that could have the effect of sabotaging the individual's goal striving intentions. Based on the above and interpreting the results of the studies it is suggested that the reason why implementation intentions did not work was due to participants having thoughts and feelings that hindered the performance of goal directed behaviours.

It was noticed that aspirations to use the Mathematics Support Centre at pre-intervention was a predictor of students' usage of the support centre post-intervention. Aspirations to use the services would have been based on individuals' relationship with mathematics at pre-intervention. Their relationship with mathematics and aspirations to use the service would have been influenced by students' self-assessment of their own mathematical ability, perception of the course requirements, comparisons of perceived ability with that of the course requirements and the role of mathematics. The implementation intention aimed to provide a stimulus-cue link to ensure the individual used the Mathematics Support Centre. However, the student's own aspirations to use or not use the services and their own evaluation of the need to use the service is likely to have diminished the effectiveness of implementation intentions.

8.3.3 Implementation intentions and Mathematics Support Centre usage

The literature has provided evidence to suggest that implementation intentions are effective in facilitating individuals to carry out goal related behaviours. However, as discussed in Sections 8.3.1 and 8.3.2, implementation intentions did not work in improving Mathematics Support Centre usage. This section aims to explore one way that implementation intentions could be used for future research looking into non-compulsory mathematical study behaviours. The strategy would aim to collect more accurate data on study habits along with an assessment of the students' relationship with mathematics in addition to actual ability measures using a mathematics diagnostic test.

At the beginning of the study the researcher would administer a questionnaire to identify an individual's relationship with mathematics in addition to a mathematics diagnostics questionnaire. Doing so would allow for the identification of a student's perceived need to use the Mathematics Support Centre. Of particular interest would be students who are low scorers on the mathematics diagnostic test but perceive their ability to be adequate for the requirements of their chosen course of study. Students would then identify areas of mathematics that they need support with at the start of an intervention study. Participants allocated to the treatment condition would then be assisted in forming implementation intentions. To gain a more accurate measure of Mathematics Support Centre usage; at the start of each week, participants would identify if they have any mathematics problems. At the end of the week they would report if their maths problem had been addressed and also how this was accomplished. Participants would need to provide details such as duration of study and frequency of study. This process would allow students to provide weekly accounts of the issues and strategies for dealing with those mathematical problems. Subsequent analysis would take into account the participants' relationship with mathematics and if they had any areas of mathematics they wished to improve.

The main difference between this strategy and those used in the past is the increase in frequency of measurement of goal directed behaviours. Increased frequency of measurement is also likely to identify usage of the Mathematics Support Centre for small mathematics problems that can be remedied with just one visit. It may also be prudent to focus on the ability of the individual to react to mathematics problems (by using the Maths Support Centre or seeking support) rather than focusing solely on the number of hours an individual used the services. It is suggested that while implementation intentions did not work when used as described in this thesis, they are still valuable constructs to aid goal directed behaviour if used in a manner similar to that described above.

8.4 LIMITATIONS OF THE RESEARCH

In carrying out the intervention and pilot studies, a number of limitations were identified; these limitations had implications on the data that was collected as well as subsequent analysis. This section aims to outline the limitations arising from the instruments, measures, data collection methods and subsequent analysis. Where possible the strategies that were used to minimise the limitations have been described.

8.4.1 INSTRUMENTS

Study habits, personality, social desirability, mathematical ability and demographics data were gathered using self report instruments. The self-report instruments were convenient in that individuals could complete all of the instruments at the same time and also by taking a minimal amount of time to complete. However, using this type of instrument also introduced the possibility of error, mistakes and inaccuracies in the reported measures. These could have been due to a variety of reasons including error in participant recollection, variances between truth and the responses given to question items or perception being mistaken for reality.

It was possible that the reports of mathematical study habits and usage of the Mathematics Support Centre were perceptions of their usage rather than an accurate measure of their usage of the services. There is no suggestion that there was deliberate deception by participants. However, their recollections of actual usage may have been inaccurate. For example an individual who only used the services for one hour over the previous month is likely to be more accurate than an individual who used the services every day with a total of approximately 45 hours over 70 visits, this larger figure may be prone to more error as the individual may not have recalled all of the visits or exact durations of each visit.

Several alternative strategies were considered to gather data on study habits; however, these also raised potentially new ethical and practical problems. Participant observation was considered as a means to gather accurate usage data. Doing so would firstly only allow data to be gathered from one location at a time and also would have required observations of usage to be made over many hours e.g. the opening hours of the location the Mathematics Support Centre. Furthermore, this would need to have been done on a daily basis for the duration of the study. To accurately record the usage of individuals it would also have been necessary to be able to recognise and distinguish participants involved in the study from users of the services not involved in the study. Lastly the observation method would not have been able to capture study behaviours taking place outside of the university (e.g. home, café or bars) as was required for the Year Long Intervention Study. The practicalities of the above strategy were not feasible due to the limited resources available during the study. Ethically it seemed questionable that a researcher should in essence be tracking individuals or groups of individuals for the majority of the day in the hope that they may engage in mathematical study. This method also seemed intrusive, as the researcher would have had to ascertain if mathematical learning was taking place when observing participants in a particular location.

A second strategy for assessing the actual usage of the Mathematics Support Centre was to use data collected by the service provider itself. Users of the services have been encouraged to provide details about themselves (name, faculty, course of study and year of study) either by scanning their university identity card under a barcode reader or by writing these details down upon entry to the centre. Providing these details were not mandatory in order to receive support. This strategy was considered as a possible means of gathering accurate usage data. However, this method also appeared inaccurate upon closer inspection. Students were not required to provide details upon entry to the service although they were encouraged to provide details when possible, this could result in users not being recorded. Furthermore, the logs (written and through identity cards) provided an estimate of the number of visits and the number of unique users only. What they did not capture was the amount of time students spent using the services within the support centre. The self-report instruments did allow data to capture the amount of time students engaged with the services. However, it is acknowledged that self-report measures are prone to inaccuracies due to the instruments relying on participants' memories of their usage and assumptions that their perceptions of usage were very close to their actual usage.

The treatment intervention was constructed such that participants were guided through a process that first required them to identify barriers that were stopping them learning mathematics and then the identification of a strategy or behaviour that could be used to study mathematics along with a time when this mathematical study behaviour could be undertaken. The second stage required the construction of implementation intentions based upon their first stage responses. However, in doing so it is difficult to ascertain if any improvements in the study habits of individuals were down to the identification of barriers and strategies or as a result of the intervention. This entanglement of the two parts of the intervention could be removed through the use of a third control group that consisted only of participants who had completed the first stage of the intervention. However, it would not be possible to ensure that participants in this group do not form implementation intentions of their own accord. Despite this it would seem sensible for a future study to include the third control group as a strategy for taking into account the influence of the instructions prior to forming implementation intentions.

The literature (Milne, Orbell and Sheeran 2002; Sheeran, Webb and Gollwitzer 2005; Prestwich, Ayres and Lawton 2008) suggests that implementation intentions are most effective when applied to volitional behaviours. The interventions used in this thesis were administered to participants who did not necessarily have intentions to use the Mathematics Support Services at Coventry University. It is possible that although implementation intentions aim to strengthen links between situational cues and behaviours, the lack of initial motivation to use the services may have contributed to the implementation intentions being ineffective.

An improved method of administering the intervention could have been to modify the intervention such that participants in both control and treatment conditions were provided with a motivational activity prior to the control and treatment tasks. The aim of the motivational activity would be to firstly raise participants awareness of their own mathematical ability and need for support, secondly it would aim to raise the appeal of using the Mathematics Support Centre as a means to improve mathematical ability regardless of current ability or type of course being studied. This could also address the issues identified by Symmonds, Lawson and Robinson (2008) regarding the perceived need and target audience of the services which were linked to low levels of motivations to use the support provision.

8.4.2 Measures

Correlations between usage measures and both psychoticism and extraversion were not consistent across the studies. Literature would suggest that conscientiousness could be a better construct to measure. A future study may wish to examine conscientiousness, psychoticism and extraversion using the NEO PI-R test instrument. During all of the studies a mathematics diagnostic was used to ascertain mathematical ability and was kept short for practical reasons. At the time of designing the instruments it was felt that a shorter diagnostic would be adequate for the purposes of the studies as mathematical ability itself was not the primary focus of this thesis. Furthermore, a shorter test was considered adequate as it both covered the main areas of GCSE mathematics and was concise enough to be completed within approximately 15 minutes. The time taken to complete the test was important as the time available for testing participants was limited. A more accurate assessment would have required a longer test (more items covering various maths topics at different difficulty levels). A longer test would have been a better option for gauging the participants' mathematical abilities. Across the university, some students (depending on the course of study) are required to take a longer mathematics diagnostic test during induction week. However, those tests varied in content and the context of the questions due to the diagnostic test being run departmentally. With hindsight it may have been an option to focus on a particular faculty or department that had a mathematics diagnostic test incorporated into their programme. This would have resulted in possibly a more accurate reflection of the mathematical ability of the participants. Unfortunately, this would also have made it more difficult to compare scores between participants from different departments as was done in both the Year Long and Term Long studies. The mathematics diagnostic tests used in the studies also focused purely on mathematical ability.

No measures looking at perceptions of mathematical ability were used, it seems plausible to suggest that there could be differences in actual ability and perceptions of ability. The use or intention to study could therefore be more dependent on the individuals perceived ability than actual ability. Furthermore, the individual's intention could be measured using a questionnaire looking at the participant's relationship with mathematics (Section 7.4.1); this would also identify feelings or attitudes that would derail or hinder the shielding effect of implementation intentions.

Data on study habits in the majority of cases deviated significantly far from normal. Some of the difference scores in the Year Long Intervention Study were close to being normal but still deviated from normality. It may be the case that these deviations were a result of some fundamental flaw in the instrument design or data collection process. However, it is suggested that even with more accurate measures of usage the data would still be severely skewed since the bulk of participants that were involved in the study did not use the services, with fewer who used the service infrequently and less still who were frequent users. This could not be corrected through transformations. Difference scores suffered from less severe skewness problems that could be remedied using transformations. However, the distributions of difference scores were severely leptokurtic and as a result were not able to be transformed into a normal distribution.

8.4.3 DATA COLLECTION METHODS

8.4.3.1 Contamination and distortion of the control and treatment groups

Students in the control group and the treatment groups were not physically separated or isolated from each other during the intervention. Although selection of participants into both groups was done randomly, the participants may have chosen to swap worksheets with other students if it was felt that one was easier or quicker to complete. As a result it may have been possible for the control and treatment groups to become distorted if certain types of students preferred one task over another and swapped worksheets accordingly, leading to an increased risk of the control group and treatment group being unrepresentative and biased. To help reduce this effect the distribution of tasks to students in the control and treatment group aimed to use the natural features of the lecture theatre to limit re-distribution of tasks by students. Lecture theatres and classrooms that were in use during the research were arranged such that students would need to sit in rows. By splitting the class into a left and right block (based on where they are sitting in relation to the lecturer) and allocating one block the control task and the other block the treatment task the ability for students to redistribute tasks was limited mainly to those who were sitting on the boundary where both blocks meet. Another strategy used was to use the rows of the lecture theatre, each row was allocated to either the control or treatment condition.

Contamination of the control group could also have occurred if those completing the treatment worksheet discussed their task with their peers in the control condition during the intervention or at some time after the scheduled intervention had taken place. The influence of participants in the control condition discussing their task with those in the treatment group was inconsequential as the tasks in the control group should not affect the construction of the implementation intention for the treatment group. By participants discussing the treatment task there could have been a reduced chance of observing the effect of the treatment. Even if the treatment was effective, members of the control group being exposed to the treatment would reduce the ability to identify the effect of the treatment. These effects were minimised by splitting the class into two blocks as described above; participants would be less likely to be aware of a difference in the task compared to their peers sitting on the other side of the class (with the exception of those sitting on the boundary). Though this does not stop contamination occurring outside of the class once the intervention is over. However, this was reduced if those students sitting near each other have the same tasks (again the boundary area is the exception) by ensuring each row in a lecture theatre was allocated to the same condition. The method used was dependent on the physical limitations and features of the room being used.

Although there was no evidence of contamination between participants, it should be kept in mind that this does not rule out any discussion between participants. Participant contamination within the treatment group could have occurred if participants discussed the tasks with each other. Responses on the worksheet would then have been peer influenced. In that situation the resulting implementation intention that was constructed in Task 4 (see Appendix 2.9) may not have been related to the participant’s actual barriers and strategies for improving their own mathematics. The plan in essence could be irrelevant to the individual and may be ineffective as it relates to situations, times or activities that the individual is unable to engage or participate with. To reduce this effect would require that participants within the treatment group first have clear and comprehensive instructions on how to complete the task; this would eliminate the need for participants to talk to peers regarding the task. Secondly to further remove contamination, the students were required to work individually and as far as possible in silence. As these students were not regularly taught by the researcher, testing conditions were maintained with the assistance of the usual lecturer.

8.4.3.2 Relapse time span

Due to the limitations in student and research availability combined with time constraints placed on the research, it was impossible to conduct a more detailed longitudinal study that measures the engagement with various study behaviours at numerous time intervals during the year (monthly or bi monthly). By only measuring the usage once at the intervention and once at the post-intervention stage it was not possible to gauge the study behaviour between those two times. The drawback with the method used was that it did not allow the researcher to observe any potential effects that may have occurred between the time the intervention was administered and the time at which the post-intervention questionnaire was completed. During that time period it was possible that a participant may have changed their behaviour and then reverted back to their pre-intervention behaviours through a relapse

(Raymond and Niaura 1999, McGovern et al. 2005). In that case the implementation intention would not have been successful in achieving a long-term change in engagement with mathematical study. So even though an effect occurred, it would not have been picked up by the post-intervention questionnaire. This inability to capture or record potential changes in behaviour occurring at times other than when the post-intervention questionnaire was completed could under estimate the effectiveness of implementation intentions. In future the study could be improved by gathering usage data at more time points during the study, possibly once per seven days.

8.4.4 Analysis

The data that were obtained deviated from normality so severely that parametric analyses could not be used. In light of this, nonparametric tests were performed that made no assumption as to the distributions of the data. It is likely that data on participants study habits is inherently not normally distributed. The consequence of this was that the analysis used was limited predominantly to performing tests individually, looking at differences and correlations between pairs of groups and variables (Chapters 5 and 6). The nonparametric analysis used in Chapters 5 and 6 also removed the ability to use more powerful statistical techniques that could allow predictions to be made about the improvements in usage and interactions between various variables. It was also not possible to explore interactions between variables.

The analysis of the Term Long Intervention Study data (Chapter 7) used the Aligned Rank Transform method to enable an ANOVA type analysis to be performed. This was an improvement over the classical non-parametric techniques that were used in the analysis of the Year Long Intervention Study data as it allowed interactions between factors to be examined. An improvement to the analysis used could be achieved by a refinement in the way data on study habits were being collected. Rather than focusing on changes in total amount of time being spent using the Mathematics Support Centre, usage data could be collected more frequently (perhaps weekly) in addition to participants providing data on the mathematics problems they currently have and how they have addressed them over the week. Coding and subsequent analysis could aim to focus on how able an individual was to deal with identified areas of mathematical development. It is suggested that focusing analysis on whether an individual is successful in using the Mathematics Support Service to address an area of development could be a better way to examine the effectiveness of implementation intentions in this context. Future work would need to take this into account both when designing instruments to measure usage of the Mathematics Support Centre.

8.5 FUTURE WORK

8.5.1 PAST RESEARCH

Past research as described in the literature suggested that there could be medium to large effects of implementation intentions on changes in behaviour. Furthermore, recent research has pointed to the formation of implementation intentions requiring the mental rehearsal of the cue and behaviour link. Self-reports are also acknowledged to be questionable in accuracy even when used in conjunction with social desirability measures.

8.5.2 Impact of limitations on further research

The major limitations of this study were the accurate measurement of study habits in particular the time spent engaged with mathematics support services. The entanglement of the intervention resulted in any improvement due to implementation intentions not being separable from effects due to other parts of the intervention. Finally, the data itself being non-parametric severely limited the predictive capability of the tests and also prevented more advanced analysis that could have revealed interaction effects.

Future research may wish to examine how usage of support centres such as the Mathematics Support Centres is measured, particularly in the case of non-mathematics students whose usage data is likely to contain a sizeable proportion of users with no engagement whatsoever. Measurement of usage needs to take into account not only the number of visits but also the type of use and the duration of use. In light of this, future research may wish to examine the usage of support centres in other institutions where appointment based support is predominantly provided. Doing so would allow usage to be accurately recorded, together with the duration of support that was provided. However, the issues relating to large numbers of zero values in the data would be harder to remedy.

8.5.3 QUESTIONS UNANSWERED IN THIS THESIS

Although the results of this thesis suggest that the use of implementation intentions were not effective in improving the usage of the Mathematics Support Centre, there are a number of questions raised relating to why this may be the case.

- Implementation intentions have been used effectively in health related behaviours. Why was there no statistically significant effect as a result of implementation intentions in the context of non-compulsory mathematical study?
- What was different about this context compared to research in other contexts where noticeably large effects have been observed?
- Ignoring the spurious and tentative nature of the effect of personality that was observed, a difference in usage was only observed between those who had aspirations to go and use the services and those who did not. Why did so many have no intention to use the services and how could this be changed?
- What influence do attitudes to mathematics learning based on past experiences have on the forming of implementation intentions? More specifically could past attitudes towards learning contexts act to reduce the effectiveness of implementation intentions and possibly nullifying their effect altogether?

8.5.4 FUTURE RESEARCH

Based on the limitations described in Sections 8.4 and 8.5.2 together with the questions raised in Sections 8.5.2 and 8.5.3, a number of areas for future research can be suggested. Firstly future research needs to address the methodological issues that were identified i.e. the accurate and meaningful measurement of the usage of the Mathematics Support Centres; focusing on ability to address mathematics needs rather than total number of hours the service was used. Secondly and more interesting is the question of why implementation intentions did not seem to have any effect on the mathematical study habits of participants in this study. The literature suggests that the use of implementation intentions is a highly effective and low cost solution for improving various behaviours predominantly health related or where a clear benefit to performing the behaviour can be seen. However, in the case of studying mathematics the will or desire to study maths is not always present itself. Future work may aim to look at attitudes towards mathematics in addition to mathematical ability. Past experiences of mathematics possibly negative may exist (e.g. Bhakta, Lawson and Goodband 2007) and influence their current attitudes towards learning mathematics. For students with negative attitudes to mathematical study it is suggested that the act of forming implementation intentions may evoke negative attitudes towards mathematical study and hence negate the effectiveness of the intervention. Future research should aim to explore why implementation intentions may not work in the context of non-compulsory educational behaviours by examining the feelings and attitudes that implementation intentions do not shield against. Furthermore, attempts should be made to understand how the intervention could be modified or used in conjunction with other interventions to enable implementation intentions to become effective in the context of education.

8.6 Conclusions and recommendations based on the current research

Based on the results there is little evidence to support the hypothesis that the formation of implementation intentions can improve the usage of mathematics support services in a university context. The biggest difference in usage was between those who intended to use the services and those who had not. Until a way of implementing the use of implementation intentions in a way that is effective in bringing about behaviour change in this context is available, it would be better to focus on changing the students' intention to use the services by raising awareness of the services and highlighting the need to use the services.

Research needs to focus on why this intervention does not work in the context of non-compulsory educational behaviours with a view to finding strategies to enable the intervention's effective use. Possibly through a two stage approach, first changing attitudes towards mathematical study (removal of negative attitudes) and then forming implementation intentions. Measuring the usage of Mathematics Support Centres should not just focus on the amount of usage. A better measure to use would be to ascertain the usage in response to an individual's perceived mathematical inadequacies.

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APPENDICES

APPENDIX 1.1 SUMMARIES OF THE MATHEMATICS SUPPORT OFFERED TO STUDENTS AT THREE UNIVERSITIES IN ENGLAND.

Centre for Learning Support and Development (London South Bank University)

Support is offered to students in both language and mathematics at all levels.

- Opening hours - 12pm to 3pm weekdays in addition to a Thursday session from 3.30pm to 5.30pm
- One to one sessions (20 minutes, booking required)
- Drop in workshops (no booking, any topic, open to all students)
- Topic workshops (limited to 20 students and covers a specific topic)
- Nursing topic sessions (nursing mathematics calculation specific)
- Drop in nursing sessions (non-specific nursing mathematics)
- Pre-entry summer school (6 week course run for 3 hours everyday at either GCSE or A-level standard)

Mathematics Support Centre (sigma, Coventry University)

The Mathematics Support Centre aims to supplement the support offered by other departments with regards to mathematics and statistics.

- Opening hours 11pm to 5pm during week days (except Tuesday and Fridays where the closing times are 7pm and 4pm respectively)

- Drop in mathematics workshops (available to all students across the university)
- Statistics Advisory Service is available for both final year students (major project only) and postgraduate students from any discipline. Support is in the form of a 1 hour appointment which is booked online
- Drop in statistics workshop run for 1 hour at lunchtimes 3 days a week.
- A dedicated website to help support students (http://www.coventry.ac.uk/ec/maths_centre/)
- A repository of worksheets, presentations and information sheets that can be downloaded by students
- Online diagnostics for students to asses their own mathematical ability
- Students are also able to email mathematics problems to the Mathematics Support Centre via email if they are unable to visit the centre
- Videos/podcasts available from the maths centre website (http://www.mathcentre.ac.uk/)
- Paper based resources available in the Mathematics Support Centre include a variety of handouts on mathematical topics and a small library of mathematics texts
- Trialling of mathematics drop in workshops located in the Health and Life Sciences department (during 2006/2007 and aimed solely at nursing students)

Maths Application of Number Group at QMC (University of Nottingham)

The Maths Application of Number Group for Nursing Students consists is a support groups consisting of 10 to 12 core members of staff and others who are associated with it. Their aim is to support nursing students by helping them to develop the mathematical skills that of direct relevance to their chosen vocation (e.g. addition, subtraction, multiplication, division and SI units and to a smaller extent the interpretation of graphs and data).

- Diagnostic test for all nursing students given by the university to assess skills in addition, subtraction, multiplication and division, students are aware of their ability and can if they so choose use the support group
- Information on other support materials are made known to the students via the group (books, websites etc). – for examples and questions
- Non-prescriptive support, students are offered numerous methods and materials for understanding a problem. The student is able to choose which works best in their case
- Personal tutorials – 1 hour sessions booked in advance and repeated as often as necessary, not compulsory. – for explanation and help with the underlying concepts
- Computer assisted learning packages using visually relevant contexts for

questions and examples such as use of drips and syringes, test tubes (and to help with estimation too) – students work at their own pace. (accessed on site only) and WEB CT

APPENDIX 2.1 DIAGNOSTIC TEST USED BY THE FACULTY OF ENGINEERING AND COMPUTING AT COVENTRY UNIVERSITY.

COVENTRY UNIVERSITY

MATHEMATICS SUPPORT CENTRE

DIAGNOSTIC TEST

Question 1

The value of $9 - (3 + 4)$ is

A: 10 B: 2 C: 165 D: 85 E: Don't know

Question 2

The value of $3 + (-5)$ is

A: -8 B: 2 C: -2 D: 8 E: Don't know

Question 3

The value of $4 \times (-5)$ is

A: 9 B: -1 C: -20 D: 20 E: Don't know

Question 4

The value of $4 + 3 \times 2$ is

A: 14 B: 10 C: 9 D: 7 E: Don't know

Question 5

The value of $10 - 4 \div 2$ is

A: 7 B: 3 C: 8 D: 1 E: Don't know

Question 6

The value of $8 - (5 - 3)$ is

A: 6 B: 0 C: 16 D: 10 E: Don't know

Question 7

The value of $\frac{1}{5}$ as a decimal is

A: 0.15 B: 0.5 C: 0.1 D: 0.2 E: Don't know

Question 8

The value of $\frac{1}{4}$ as a decimal is

A: 0.4 B: 0.14 C: 0.25 D: 0.04 E: Don't know

Question 9

The value of 0.02 as a fraction is

A: $\frac{1}{50}$ B: $\frac{1}{5}$ C: $\frac{1}{2}$ D: $\frac{1}{20}$ E: Don't know

Question 10

The value of 0.3 as a fraction is

A: $\frac{1}{3}$ B: $\frac{3}{10}$ C: $\frac{3}{100}$ D: $\frac{1}{30}$ E: Don't know

Question 11

The value of $\frac{7}{10}$ as a percentage is

A: 7% B: 50% C: 10% D: 70% E: Don't know

Question 12

The value of 40% as a fraction is

A: $\frac{1}{4}$ B: $\frac{2}{5}$ C: $\frac{1}{40}$ D: $\frac{1}{10}$ E: Don't know

Question 13

If £60 is divided between two people A and B in the ratio 5:7, then A gets

A: £35 B: £25 C: £5 D: £15 E: Don't know

Question 14

If a sum of money is divided between two people A and B in the ratio 3:2 and B receives £10 then A gets

A: £3 B: £15 C: £6 D: £30 E: Don't know

Question 15

The profits of a company are divided between three directors A, B and C in the ratio 2:2:1. If A receives £6000 then the total profit is

A: £15000 B: £18000 C: £1200 D: £2400 E: Don't know

Question 16

If the cost of printing a book with 200 pages is £6.24 then the cost of printing a book with 150 pages is

A: £5 B: £4.50 C: £3.12 D: £4.68 E: Don't know

Question 17

If 5 machines take 40 hours to complete a production run then the time it takes to complete a similar order using 2 machines is

A: 16 hours B: 20 hours C: 100 hours D: 80 hours E: Don't know

Question 18

134521 to the nearest 1000 is

A: 135 B: 135000 C: 134500 D: 134000 E: Don't know

Question 19

21.43×0.19 is approximately

A: 20 B: 10 C: 2 D: 4 E: Don't know

Question 20

$\frac{7.\dot{2}103 + 4.92}{1.01 - 0.3875}$ is approximately

A: 20 B: 6 C: 12 D: 11 E: Don't know

Question 21

The value of $\sqrt{\frac{91.3}{10.1}}$ estimated to one significant figure is

A: 1 B: 10 C: 4 D: 3 E: Don't know

Question 22

When we subtract 2.1476 from 4.002 we get

A: 1.8526 B: 1.855 C: 1.8544 D: 2.1496 E: Don't know

Question 23

The value of $\frac{2}{5}+\frac{1}{15}$ is

A: $\frac{7}{15}$ B: $\frac{3}{20}$ C: $\frac{4}{15}$ D: $\frac{3}{15}$ E: Don't know

Question 24

The value of $\frac{1}{2}+\frac{3}{7}$ is

A: $\frac{13}{14}$ B: $\frac{4}{9}$ C: $\frac{9}{14}$ D: $\frac{23}{14}$ E: Don't know

Question 25

A field has an area of $1\frac{3}{5}$ hectares and carrots are planted on $\frac{1}{2}$ hectare. The area of land available for planting potatoes is

A: $\frac{7}{10}$ B: $\frac{4}{7}$ C: $1\frac{2}{3}$ D: $1\frac{1}{10}$ E: Don't know

Question 26

The value of $\frac{3}{5}\times\frac{7}{8}$ is

A: $\frac{37}{58}$ B: $\frac{10}{13}$ C: $\frac{21}{40}$ D: $\frac{24}{35}$ E: Don't know

Question 27

The value of $\frac{3}{4}\div\frac{2}{3}$ is

A: $\frac{1}{2}$ B: $\frac{9}{8}$ C: $\frac{8}{9}$ D: $\frac{5}{7}$ E: Don't know

Question 28

10% of £30 is

A: £10 B: £0.30 C: £3 D: £6 E: Don't know

Question 29

20% of £50 is

A: £10 B: £20 C: £5 D: £40 E: Don't know

Question 30

25% of £360 is

A: £90 B: £25 C: £36 D: £72 E: Don't know

Question 31

£30 as a percentage of £120 is

A: 30% B: 40% C: 90% D: 25% E: Don't know

Question 32

£6 as a percentage of £200 is

A: 6% B: 12% C: 3% D: 60% E: Don't know

Question 33

When 250 is increased by 5% the value is

A: 255 B: 237.5 C: 300 D: 262.5 E: Don't know

Question 34

When 75 is decreased by 10% the value is

A: 85 B: 65 C: 67.5 D: 82.5 E: Don't know

Question 35

A portfolio of shares is sold for £1800 which is a loss of 10%. The original cost of the shares was

A: £1980 B: £2000 C: £1620 D: £1790 E: Don't know

Question 36

When 1.5 is multiplied by 0.3 the answer is

A: 0.045 B: 4.5 C: 45 D: 0.45 E: Don't know

Question 37

The expression $5x - 3y + 2x + y$ is equal to

A: $3x - 4y$ B: $7x - 4y$ C: $3x - 2y$ D: $7x - 2y$ E: Don't know

Question 38

The expression $3x^2 - 2(x - x^2)$ is equal to

A: $x^2 - 2x$ B: $2x^2 - 2x$ C: $5x^2 - 2x$ D: $4x^2 - 2x$ E: Don't know

Question 39

The value of $3x + 2y$ when $x = 3$ and $y = 4$ is

A: 5 B: 18 C: 7 D: 17 E: Don't know

Question 40

If $2x + 1 = 9$ then x must equal

A: 4 B: 3.5 C: 5 D: 8 E: Don't know

Question 41

If $5(x-3)=30$ then x must equal

A: $\frac{33}{5}$ B: 22 C: 9 D: 3 E: Don't know

Question 42

If $x+2=3x-4$ then x must equal

A: 3 B: $-\frac{1}{2}$ C: 2 D: -3 E: Don't know

Question 43

If $3x-2y=5$ and $x+2y=-1$ then x must equal

A: 2 B: 3 C: 1 D: 3/2 E: Don't know

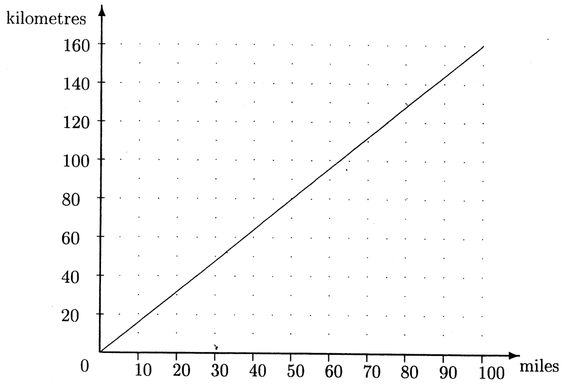
Question 44

If $y=mx+c$ then x is equal to

A: $\frac{y}{m}-c$ B: $\frac{y}{m}+c$ D: $my+c$ D: $\frac{y-c}{m}$ E: Don't know

Continued on next page.

Use this conversion graph to answer questions 45, 46 and 47



Question 45

Two towns are 80 miles apart. This is approximately

A: 50 km B: 160 km C: 100 km D: 130 km E: Don't know

Question 46

A car travels 50 kilometres. This is approximately

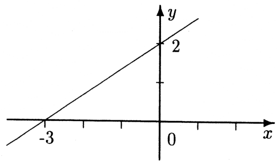
A: 30 miles B: 80 miles C: 40 miles D: 90 miles E: Don't know

Question 47

The speed limit on motorways is 70 miles per hour. This is approximately

A: 45 km/hr B: 70 km/hr C: 110 km/hr D: 140 km/hr E: Don't know

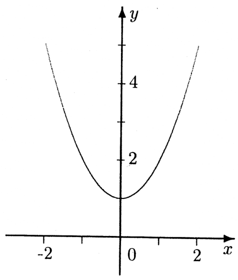
Question 48



This is the graph of

A: $y = 3x - 2$ B: $y = 3x + 2$ C: $y = \frac{2}{3}x - 2$ D: $y = \frac{2}{3}x + 2$ E: Don't know

Question 49



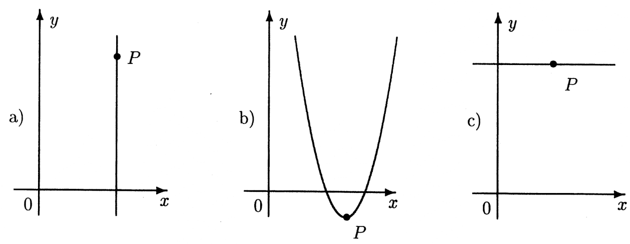
This is the graph of

A: $y = x + 1$ B: $y = x^2 - 1$ C: $y = x^2 + 1$ D: $y = x^2$ E: Don't know

Continued on next page.

Question 50

The gradient at the point P is zero for the curves in diagrams



A: a) only B: b) and c) only C: a) and c) only D: a), b) and c) E: Don't know

Appendix 2.2 Mathematics Diagnostic Version A

Student Number:

0.0045 x 10 =

62 x 3.6 =

400 divided by 50 =

Divide the quantity of 105cm into 2 parts in the ratio of 3:4

5% of 300 =

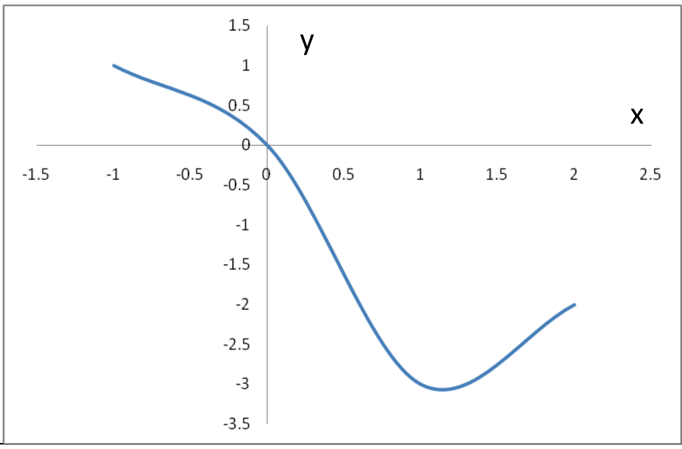
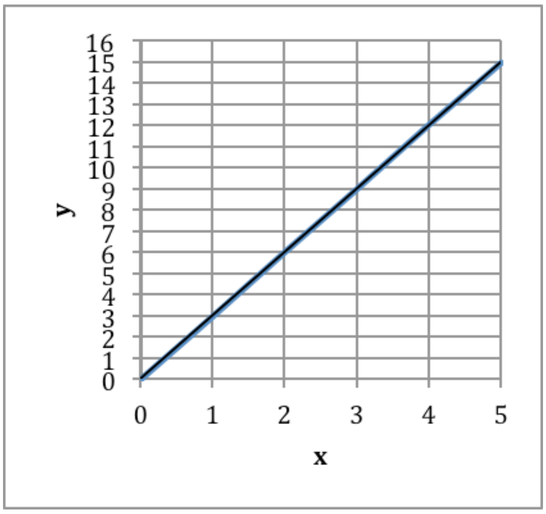
Convert 47ml into litres =

Which is larger 0.02 litres or 0.006 litres?

APPENDIX 2.3 MATHEMATICS DIAGNOSTIC VERSION B

Please answer the following seven questions by working out the answer to each one WITHOUT using a calculator. If you need to do any rough working, you may use either the front or back of this page. **Please write your answer in the column marked "Answers"**.

	Answers
Q.1) 0.0045 x 10 =	*Q.1)*
Q.2) 62 x 3.6 =	*Q.2)*
Q.3) Divide the quantity of 105cm into 2 parts in the ratio of 3:4	*Q.3)*
Q.4) 5% of 300 =	*Q.4)*
Q.5) Convert 47ml into litres =	*Q.5)*
Q.6) Which is larger 0.02 litres or 0.006 litres?	*Q.6)*

	Answers
Q.7) What is the approximate value of y when x = 1.5? 	*Q.7)*
Q.8) What is the gradient of the line in the graph shown below? 	*Q.8)*
Q.9) Rearrange the equation below to make *x* the subject of the formula. $y = 3x + b$	*Q.9)*

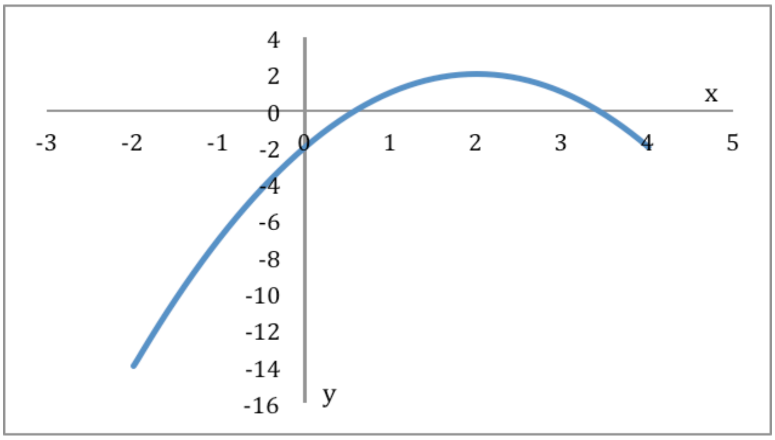
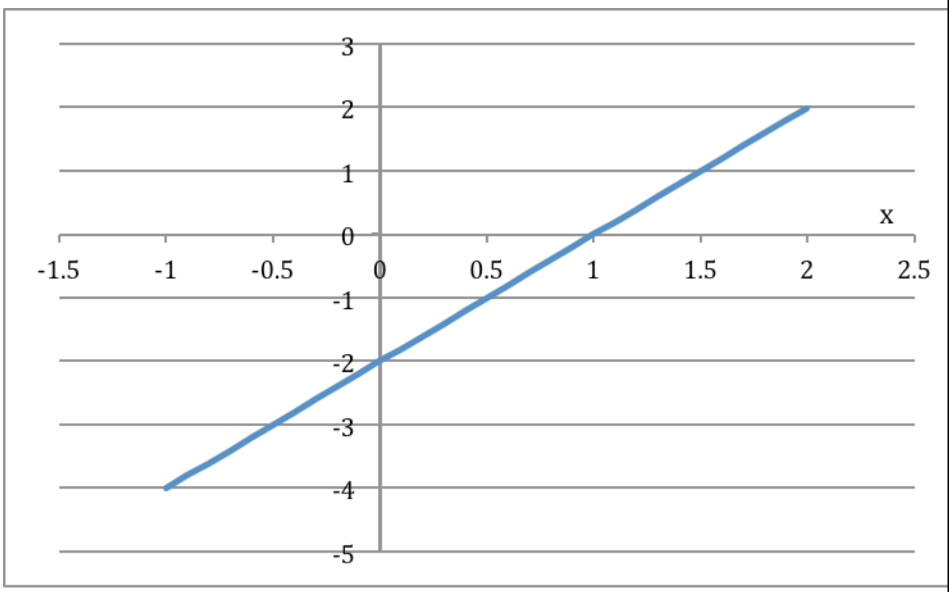
Q.10) Calculate the value of Z when a = 2 and b = 3 $Z = 4a + b^2$	*Q.10)*

APPENDIX 2.4 MATHEMATICS DIAGNOSTIC VERSION C

Please answer the following seven questions by working out the answer to each one WITHOUT using a calculator. If you need to do any rough working, you may use either the front or back of this page. **Please write your answer in the column marked "Answers"**.

	Answers
Q.1) 0.0064 x 10 =	*Q.1)*
Q.2) 68 x 4.2 =	*Q.2)*
Q.3) Divide the quantity of 72cm into 2 parts in the ratio of 3:5	*Q.3)*

Q.4) 5% of 460 =	*Q.4)*
Q.5) Convert 82ml into litres =	*Q.5)*
Q.6) Which is larger 0.01 litres or 0.007 litres?	*Q.6)*

	Answers
Q.7) What is the approximate value of y when x = -1.5? 	*Q.7)*
Q.8) What is the gradient of the line in the graph shown below? 	*Q.8)*

Q.9) Rearrange the equation below to make *x* the subject of the formula. $y = b - 2x$	*Q.9)*
Q.10) Calculate the value of *Z* when *a* = 2 and *b* = 3 $Z = b^2 + 3a$	*Q.10)*

Appendix 2.5 Mathematics Study Behaviours Version A

*Student number:*__________

Studying as a student

The following two sections will ask you about your study habits and in particular how often you take part in different types of study.

Intended usage

This section looks at how often you intend or feel you need to study using various methods. The aim of this section is to find out how often you would like to study and in what ways you would like to study if there was nothing stopping you from studying.

As an example, think about going to the gym to exercise. Many people do have the best intentions of going to the gym and do feel it is a worthwhile activity, a student may say they plan on going to the gym 5 times a week, but only go 2 times. For this section the student would talk about his plan to go to the gym 5 times a week only

When completing this section do not worry if you actually did or did not do follow through and study in the particular ways you have described. All that is required is for you to describe how you might study in an idea world situation.

1. Do you know of any support offered by the university designed to help students with numeracy or mathematics related problems?

2. Please fill in the blank spaced in the table by answering the following question:

When engaged in mathematics related study, how many hours would you plan to spend studying in the following ways in any one month?

ACTIVITY	Number of hours (approximately)
Using text books (reading and working on questions)	
TV resources	
Working in the library	
Find peer support	
Mathematics support centre	
Internet resources	
Talking informally and formally to staff	
Timetabled tutorials and workshops	

3. How many visits did you intend to make to the mathematics support services over the last month (include those times you've planned to go but for some reason ended up not going or using the service?)

4. Ideally, how often (number of visits) would like to use the mathematics support services offered by the University to get help with numeracy or mathematics problems over the next month?

5. Of all of the ways in which you can improve your mathematics, which one method do you feel is the most useful?

6. How often (number of visits) would you like to use the mathematics support which is on offer over the next month?

7. How many hours do you think you would spend receiving mathematics support from the university over the next month?

8. Of all of the ways in which you can improve your mathematics, which one method do you feel is the least useful?

9. Thinking about your own mathematics and what is expected of you, how many hours of university support do you think you will need over the next month?

Actual Usage

The aim of this section is to explore how you as student tend to study. It is the actual number of time you make use of a particular study strategy or resource that is being looked at here.

As an example, think about going to the gym to exercise. Many people do have the best intentions of going to the gym and do feel it is a worthwhile activity, a student may say they plan on going to the gym 5 times a week, but only go 2 times. For this section the student would talk about his actual attendance at the gym which was 2 times.

When completing this section do not worry if you intended to study more or less frequently in any particular way. You only need to answer the number of visits or the duration of time spent studying.

1. On average, how often (no of visits) do you make use of the mathematics support offered by the university in a typical month?

2. If using mathematics support, how long on average is each visit or use of the mathematics support service?

3. Please fill in the blank spaced in the table by answering the following question:

When engaged in mathematics related study, how many hours did you spend studying in the following ways over the last month?

ACTIVITY	Number of hours (approximately)
Using text books (reading and working on questions)	
TV resources	
Working in the library	
Find peer support	
Mathematics support centre	
Internet resources	
Talking informally and formally to staff	
Timetabled tutorials and workshops	

4. If you do use any kind of university provided support services to improve your mathematics, when do you use the service most?

    a. Nearer to exam

    b. When there are no exams

    c. Services used the same throughout the year

    d. Services not used

5. How frequent were your visits to the mathematics support services on offer during the time mentioned in question 10?

    a. Never

    b. between 1 and 2 visits per month

    c. between 3 and 5 visits per month

    d. between 6 and 10 visits per month

    e. over 10 visits per month5 choices for this question.

6. If you do use any kind of university provided support services to improve your mathematics, when do you use the service least?

    a. Nearer to exams

    b. When there are no exams

    c. Services used the same throughout the year

    d. Services not used

7. How frequent were your visits to the mathematics support services on offer during the time mentioned in question 12?

    a. never

    b. between 1 and 2 visits per month

    c. between 3 and 5 visits per month

    d. between 6 and 10 visits per month

    e. over 10 visits per month

APPENDIX 2.6 MATHEMATICS STUDY BEHAVIOURS VERSION B

Study Habits Questionnaire

SECTION 1 of 2

Q.1) Please write down your STUDENT NUMBER and UNIVERISTY EMAIL/LOGON e.g. ***rosea@coventry.ac.uk*** or ***rosea*** in space provided.

Student number:

University EMAIL /LOGON:

SECTION 2 of 2

This section of the questionnaire aims to look at your study habits when you are studying mathematics or working on problems involving mathematics (not including lectures). The example below will help you complete the questions in this section.

EXAMPLE:
Paul is a student and feels he needs help with his mathematics. Over the past month he has spent 15 hours studying mathematics (involving a number of activities in different locations). While studying in the library and at home over the past month he has spent **3** hours completing practice exam questions for his final year numeracy test. Paul feels that he would like to spend more time working on questions, hopefully around **10** hours a month. However in reality he thinks he will spend **4** hours at most over the next month doing practice questions. Paul would write this in table as shown below:

LOCATION (tick one or more of the options below)				**ACTIVITY**	**HOURS**		
Library	Timetabled tutorials and workshops	Mathematics Support Centre	Other Locations		ACTUAL (past month)	ASPIRATION (next month)	ESTIMATE (next month)
				Using peer support			
x			x	Completing practice questions or exam questions	**3**	**10**	**4**

QUESTIONS:
Q.1) Do you know of any support offered by the university designed to help students with numeracy or mathematics related problems (YES or NO)? ___________

Q.2) Fill in the table below by writing down how many **HOURS** you would spend DOING the activities listed in the '**ACTIVITY**' column to help you to study MATHEMATICS. Also tick where you perform these activities (**LOCATION**). If you do not perform a particular activity leave that row blank.

LOCATION (tick one or more of the options below)				**ACTIVITY**	**HOURS**		
Library	Timetabled tutorials and workshops	Mathematics Support Centre	Other Locations		ACTUAL (past month)	ASPIRATION (next month)	ESTIMATE (next month)
				Using peer support (i.e. working with other students)			
				Completing practice questions or exam questions			
				Internet resources (university and non-university)			
				Talking informally and formally to staff			
				Reading text books			
				Television resources			

APPENDIX 2.7 MATHEMATICS STUDY BEHAVIOURS VERSION C

Study habits and mathematics

SECTION 1 of 3

IMPORTANT - Please write down your name clearly (BLOCK CAPITALS) in space provided to the right.

Name:

SECTION 2 of 3

This section of the questionnaire aims to explore the study habits of students at Coventry University. Of particular interest is how you make use of services provided by the university. For example of the drop-in services offered by the Maths Support Centre located in the Armstrong Sideley Building (Room AS327). The service is free for all undergraduate and post-graduate students at Coventry University who may want help with their numeracy or mathematics.

You will be asked to describe your use of **Maths Support Centre** over the past month together with your predicted usage over the next month. of and also how often you think you would use this service in the future you work on improving your numeracy and maths skills. In particular the questions will ask about how much time you actually work on improving maths compared to what you would like to spend.

EXAMPLE:
A student visited the Maths Support Centre 6 times and has spent 5 hours trying to improve their numeracy skills during the last month. The time was split between reading text books (2 hours), talking to staff (1 hours) and completing practice exam questions 2 hours). Over the next month the same student would like to spend 10 hours (over 9 visits) working on their numeracy but estimates that they will only spend 7 hours (over 4 visits) studying. The student would complete the table as shown below:

		Activity performed in the Maths Support Centre							Visits
		Using peer support (i.e. working with other students)	Completing practice questions or exam questions	Internet resources	Talking informally and formally to staff	Reading text books	Other		
Hours of study	ACTUAL (past month)	-	2	-	1	2	-		6
	ASPIRATION (next month)	-	5	-	2	3	-		9
	ESTIMATE (next month)	-	2	-	3	2	-		4

QUESTIONS:
Fill in the table below by writing down how many **HOURS** you would spend DOING the activities listed in the '**ACTIVITY**' columns to help you improve your maths. If you do not perform a particular activity leave that row blank.

		Activity performed in the Maths Support Centre							Visits
		Using peer support (i.e. working with other students)	Completing practice questions or exam questions	Internet resources	Talking informally and formally to staff	Reading text books	Other		
Hours of study	ACTUAL (past month)								
	ASPIRATION (next month)								
	ESTIMATE (next month)								

APPENDIX 2.8 MARLOWE CROWNE SOCIAL DESIRABILITY SCALE

Read each of the following statements carefully. For each statement indicate if you agree or disagree with it by placing a tick in either the True (agree) or the False (disagree) column next to the statement.

Q	Statement	True	False
1	Before voting I thoroughly investigate the qualifications of all the candidates.		
2	I never hesitate to go out of my way to help someone in trouble.		
3	It is sometimes hard for me to go on with my work, if I am not encouraged.		
4	I have never intensely disliked anyone.		
5	On occasion I have had doubts about my ability to succeed in life.		
6	I sometimes feel resentful when I don’t get my way.		
7	I am always careful about my manner of dress		
8	My table manners at home are as good as when I eat out in a restaurant.		
9	If I could get into a movie without paying and be sure I was not seen, I would probably do it.		
10	On a few occasions, I have given up doing something just because I thought too little of my ability.		
11	I like to gossip at times.		
12	There have been times when I felt like rebelling against people in authority even though I knew they were right.		
13	No matter who I’m talking to, I’m always a good listener.		
14	I can remember “playing sick” to get out of something.		
15	There have been occasions when I took advantage of someone.		
16	I’m always willing to admit it when I make a mistake.		
17	I always try to practice what I preach.		
18	I don’t find it particularly difficult to get along with loud-mouthed, obnoxious people.		

19	I sometimes try to get even rather than forgive and forget.		
20	When I don't know something I don't at all mind admitting it.		
21	I am always courteous, even to people who are disagreeable.		
22	At times I have really insisted on having things my own way.		
23	There have been occasions when I felt like smashing things.		
24	I would never think of letting someone else be punished for my wrongdoings.		
25	I never resent being asked to return a favour.		
26	I have never been irritated or vexed when people expressed ideas very different from my own.		
27	I never make a long trip without checking the safety of my car.		
28	There have been times when I was quite jealous of the good fortune of others.		
29	I have almost never felt the urge to tell someone off.		
30	I am sometimes irritated by people who ask favours of me.		
31	I have never felt that I was punished without cause.		
32	I sometimes think when people have a misfortune they only got what they deserved.		
33	I have never deliberately said something that hurts someone's feelings.		

APPENDIX 2.9 INTERVENTION VERSION A

Control Version A

This part of the questionnaire aims to explore how you perceive the idea of infinity and how it might be related your personality. To complete this section of the questionnaire you do not need to perform any mathematics. All you need to do is answer the following questions as best you can in any way you can. I.e. feel free to use maths notation, pictures or just a verbal description.

There is no wrong answer in the same way no answer you give is any more right that an answer another person may have. What is important here is that you try and describe your feelings or answer as clearly as possible.

Task 1

Q.1) Have you ever come across the words 'INFINITE' or 'INFINITY' (YES or NO)? ________________

Q.2) Write down three words or phrases which you might use to describe 'INFINITY' or 'INFINITE'

1. ____
2. ____
3. ____

Task 2

Q3) Give an example of something you feel maybe infinite? ____
____
____
____

Q4) Which of the following statements best describes infinity for you (Tick the one you agree with most)?

1. Infinity is similar to doing something over and over again and never stopping, there cannot be an end to it. ___________
2. Infinity can be thought of as having an end point, the result at the end of all the repetitions.____________

Task 3

Q5) Imagine how you would represent infinity on paper using a diagram to help explain the idea to a person who didn't understand what it was. Quickly sketch out the image you had in your mind in the space provided below.

Treatment Version A

As part of the research in to study habits and barriers to learning mathematics, this short task is intended to explore what you feel helps or hinders you from studying mathematics. Please complete the task by following the instructions and writing your answers in the spaces provided.

Task 1

Think of three obstacles that you feel are stopping you from improving your mathematics skills.

1. ____
2. ____
3. ____

Now circle the one you think is the biggest barrier or obstacle

Task 2

Think of how you study, write down the three ways in which you might improve your mathematical skills.

1. ____
2. ____
3. ____

Now circle the one you think would be the most effective in improving your mathematical skills

Task 3
In Task 2 you circled a way you might improve your mathematical skills. Spend a minute to think about the above activity and **why would you** wish to perform it. Also consider what you might do to perform the activity (**when could you** perform or carry it out, **where would you** do the activity?).

Why would you? ____

When would you?____

Where would you?____

Task 4
You are now going to construct a plan that describes how you are going to accomplish the activity or way of improving your mathematics that you circled in **Task 2** by describing when and/or where you plan to carry out the activity. The plan should look similar to one of the example shown below:

"If [*Why would you?*] and [*When or Where would you?*] then [*Activity circled in Task 2*]"

"If [e.g. I have a problem with maths] and [e.g. *it is Wednesday*] then [e.g. *I will go to the support centre*]"

Write down your plan below:

- ____

Copy your plan 2 more times

____
____

In your head read the plan to yourself 2 more times

APPENDIX 2.10 INTERVENTION VERSION B

As part of the research in to study habits and barriers to learning mathematics, this short task is intended to explore what you feel helps or hinders you from studying mathematics. Please complete the task by following the instructions and writing your answers in the spaces provided.

Task 1

Write down three area of maths that you feel you could improve on or would like help with.

1. ____
2. ____
3. ____

Task 2

Think of three obstacles that you feel are stopping you from improving your mathematics skills.

1. ____
2. ____
3. ____

Task 3

The university offers the mathematics support centre as a service to help students improve their maths skills. Think back to task 1 and the areas of maths you would like to improve.

If you were to improve these skills using the maths support centre think about when would be the most convenient time to make use of the services during normal opening hours, think about when you feel you would most likely go bearing in mind your other potential commitments over the next month? (your answer could be a day of the week or a particular time, however be realistic and as specific as possible)

Answer____

Task 4

You are now going to construct a plan that describes how you are going to accomplish your goal of working on the areas of maths identified in **task 1**. You are going to plan out how you are going to improve your maths using the Maths Support Centre.

"If I have a problem with **[*maths topics or areas (from Task 1)?*]** and **[*When you would use the support (from Task 3)?*]** then I will go to the Maths Support Centre"

"If I have a problem with [*e.g. ratios and trigonometry*] and [e.g. *it is Wednesday afternoon*] then I will go to the Maths Support Centre"

Write down your plan below:

- ____

Copy your plan 2 more times

____
____

In your head read the plan to yourself 2 more times

APPENDIX 2.11 DEMOGRAPHICS VERSION A

*Student Number:*__________

Before beginning the main part of the questionnaire, it would be helpful if you could answer several questions about yourself. As with the rest of the questionnaire all of your responses will be kept anonymous. (please circle the correct answer or fill in the answer in the space provided).

1) What is your age?

   ________ years

2) What is your gender?

   - Male
   - Female

3) Do you have a mathematics qualification?

   - Yes
   - No

4) If you have a mathematics qualification, could you please type the name of it below, e.g. O-level, GCSE or A-Level etc. (write down the higher one if you have more than one qualification)

   ____

5) What grade did you achieve in this qualification?

   ____

6) How many years ago did you obtain this qualification (to the nearest year)?

   ________ years

7) What is the name of the course you are studying on?

8) What is your year of study? (1st, 2nd, 3rd, 4th)

   - 1st
   - 2nd
   - 3rd
   - 4th

1) What is your mode of study?

   - Full time study
   - Part time study

2) Which of the following best describes your student status:

   - Home
   - EU
   - International student

APPENDIX 2.12 DEMOGRAPHICS VERSION B

Before beginning the main part of the questionnaire, it would be helpful if you could answer several questions about yourself. As with the rest of the questionnaire all of your responses will be kept anonymous. (please circle the correct answer or write the answer in the space provided).

<table>
<tr><td>Q.1) What is your age?

________ years</td><td>Q. 2) What is your gender?
• Male
• Female</td></tr>
<tr><td colspan="2">Q.3) If you have a mathematics qualification, please fill in the details below:
Type of qualification, e.g. O-level, GCSE or A-Level etc
____
(write down the higher one if you have more than one qualification)

Grade achieved
____

Year obtained
____</td></tr>
<tr><td>Q.4) What is the name of the course you are studying on?

____</td><td>Q.5) What is your year of study? (circle your answer)
• 1st
• 2nd
• 3rd
• 4th
• 5th or above</td></tr>
</table>

Q.6) What is your mode of study? (circle your answer) • Full time study • Part time study	Q.7) Which of the following best describes your student status? (circle your answer) • Home • EU • International student

APPENDIX 2.13 DEMOGRAPHICS VERSION C

Before beginning the main part of the questionnaire, it would be helpful if you could answer several questions about yourself. As with the rest of the questionnaire all of your responses will be kept anonymous. (please tick the most appropriate answer or write the answer in the space provided).

Q1) What is your age (please tick)?

16 to 20		31 to 40	
21 to 25		41 to 50	
26 to 30		51 or above	

Q2) What is your gender (please tick)?

Male	
Female	

Q3) What is the Highest level of maths qualification you have obtained* (please tick)?

0	No maths qualification	
1	GCSE (Grades D to G), Key Skills (level 1), BTEC Introductory Diploma and Certificates	
2	GCSE (Grades A* to C), Key Skills (level 2), BTEC First Diploma and Certificates	
3	A-levels, International Baccalaureate, NVQ (level 3), Key Skills (level 3)	
4	Any maths qualification higher than those above (e.g. degree or masters)	

**Based on National Qualifications Framework*

Q4) In what year did you achieve the qualification ticked in?___________________

Q5) What is your year of study (please tick)?

Year 1		Year 2		Year 3		Year 4	

Q6) What is your mode of study? (circle your answer)

Full time study		Part time study	

Q.7) Which of the following best describes your student status? (circle your answer)

Home		EU		International student	

APPENDIX 2.14 RECRUITMENT LEAFLET

centre for excellence
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in mathematics & statistics support

How do you study?

Researching Student Study Habits

The research

Students at Coventry University are being asked to volunteer to participate in a research project aimed at exploring their personalities and study habits when learning mathematics.

What would you need to do?

If you decide to participate, you may be asked to complete a short questionnaire or take part in a short interview (no longer than 15 minutes).

What is in it for you?

- Explore your own study behaviour and identify ways to improve the effectiveness of your own study techniques

Find out more and get involved!

For more details about the research and how you can participate, please visit the webpage below:
http://www.roybhakta.co.uk/researchinfo.aspx

APPENDIX 2.15 COVER LETTER AND INFORMATION SHEET

[redacted]

Personality and study habits of non mathematics specialists when involved in mathematical study

(Questionnaire)

Participant Information Sheet (student)

What is the purpose of the study?

The study will focus on the study habits of students at Coventry University when involved in mathematics related study.. It will focus on those studying for degrees in disciplines where an element of mathematics is needed such as business and nursing. The aim is to identify factors that have an effect on the learning experience with a particular focus on the learners' experience and usage of support mechanisms in the university environment. We wish to explore factors which determine usage of and engagement with the mathematics support centre. We hope to be able to use the findings of the study to improve the learning experience of future students at the University.

Why have I been chosen?

Because you are a student at Coventry University who has a mathematical element in your course.

Do I have to take part?

No, you have the right to refuse – we are asking for volunteers. There are no consequences if you decide not to take part.

What will I have to do?

You will participate by completing a short questionnaire which should take no more than 30 minutes to complete. Roy Bhakta from Coventry University will provide the questionnaires and provide you with further information relating to the questionnaire if you require it.

A small number of students will be invited to take short interviews about their views on mathematics support. If you are one of these students, the data from the interviews will be combined with the data from this questionnaire.

What are the possible benefits of taking part?

The study will help us understand better the factors that affect students' usage of mathematics support services and should help us to design more effective programmes of support for students. Through participation in the research, students will be able to explore their own study behaviour and possibly identify factors which may inhibit their effectiveness. Participants may also be able to identify ways in which they can improve the effectiveness of their study techniques.

What are the possible disadvantages and risks of taking part?

There are no perceived disadvantages or risks in taking part, apart from the time required for completing the questionnaire. If required, students are reminded to make arrangements for childcare, work cover etc. in advance of completing the questionnaire.

Will my taking part in this study be kept confidential?

Yes – your name and personal details will not be used in any report about the research.

Student names and personal details will not be used in any report about the research. Completed questionnaires will be held securely in a locked cabinet and the data they contain will only be used for the purposes of this research.

Only members of the research team will have access to the completed questionnaires and recordings. Raw data relating to individuals will be kept for no longer than is necessary in order to complete the analysis and dissemination of the research. Consent forms and raw data will be stored in locked cabinets in separate locations. All results will be reported in a way that preserves confidentiality.

A unique identification number will be allocated to all of the data you provide. This code is only for the purpose of linking the interview data (if you decide to participate in an interview) to the questionnaire data. Only the researcher (Roy Bhakta) will have access to your student number and unique identification number, once all the data has been collected it will tagged with your unique identification number. Information linking you to the unique identification number will be destroyed once all the raw data has been tagged, collected and input into a computer, thus resulting in all data being anonymous.

What will happen to the results of the study?

The results will be written up into a report which will be used within SIGMA and the wider University. The data you provide will also be used as part of a PhD thesis. In addition, the results will be disseminated at mathematical education conferences and published in academic journals.

If you would like information regarding the findings and conclusions of the study, please contact Roy Bhakta via email (contact details below) and he will be able to send you a summary of the results of the research via email.

What if I have any questions or do not understand something?

You may contact Roy Bhakta (contact details below).

What happens if I decide to take part?

If you decide to take part you will first need to complete the attached consent form after which a questionnaire will be provided for you to complete. You will be given plenty of time to answer the questionnaire. What is important to remember is that it is not a test and that there are no right or wrong answers. The most important thing to remember is to be honest.

What happens if I change my mind during the research?

You are free to withdraw at any time without giving any explanation for your decision. You may also withdraw from the research up to two weeks after you provided the data. All data that you have provided for this research will be removed and destroyed.

What if something goes wrong?

You may contact Professor Duncan Lawson, SIGMA Director and Associate Dean of the Faculty of Engineering and Computing.

Contact for Further Information

If you would like further information about the study please contact Roy Bhakta (telephone 024 7688 8971 or email r.bhakta@coventry.ac.uk) or Duncan Lawson (telephone 024 7688 8975 or email d.lawson@coventry.ac.uk).

CONSENT FORM

Personality and study habits of non mathematics specialists when involved in mathematical study

Please tick the check boxes if you agree

I confirm that I have read and understand the information sheet dated February 2008 (version 5.0-Q-Pilot) for the above study and have had the opportunity to ask questions.

☐ I agree

I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason.

☐ I agree

I agree to take part in the above study outlined in the information sheet dated February 2008 (version 5.0-Q-Pilot).

☐ I agree

If asked to participate in an interview I am happy for the data to be combined with the questionnaire data.

☐ I agree

Participant Signature:

Participant Name (in capitals):

Date:

Witness Signature:

Researcher Signature

[redacted]

Dear Student

As part of Coventry University's ongoing work to improve the student learning experience, **sigma** is working to help improve support for students who use mathematics as part of their chosen courses of study. As part of sigma's work I am engaged in a PhD research project that looks at the study habits of students at Coventry University. The project focuses on those studying for degrees in disciplines where an element of mathematics is needed such as business and nursing. The aim of the research is to identify factors that have an effect on the learning experience with a particular focus on the learners' experience and usage of support mechanisms in the university environment. We hope to be able to use the findings of the study to improve the learning experience of future students at the University.

The *questionnaire* enclosed consists of four parts and should take no longer than about 30 minutes to complete. If you would like to participate then it would be helpful if you read the enclosed *Information and consent* document (which contains details about the research and your role in it). If you are happy to proceed wand would like to participate in the research, please follow the instructions below:

Step

1. Read the *Information and consent* document
2. Sign the *consent form* (attached to the end of the *Information and consent sheet*)
3. Complete all four sections of the *questionnaire (Section A, Section B, Section C and Section D)*
4. Place both the *consent form* and the *questionnaire* into a sealed envelope and address it to:

Roy Bhakta
Sigma – Mathematics Support Centre
Faculty of Engineering and Computing
Priory Street
Coventry University
CV1 5FB

The envelope can be returned to me by either:

a. By post (e.g. Royal Mail)

or

b. By dropping off your sealed envelope containing your responses to the reception staff of the Armstrong Siddeley building. Ask for it to be placed in the "Student Study Habits - RB" drop box. Please ensure it is addressed as correctly.

Thank you again for your cooperation and the time spend in taking part in this study.

Yours sincerely

Roy Bhakta

Research Student

APPENDIX 3.1 STUDY 2 (CONCURRENT DATA)

Normality tests for the concurrent data of the Year Long Intervention study.

Table 1: Normality tests performed on data from all of the participants

Variable	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	*df*	*p*	Statistic	*df*	*p*
Mathematics Diagnostic	0.112	284	0.000	0.972	284	0.000
Marlowe Crowne	0.077	284	0.000	0.986	284	0.008
Psychoticism	0.129	284	0.000	0.945	284	0.000
Extraversion	0.117	284	0.000	0.955	284	0.000
Neuroticism	0.073	284	0.001	0.984	284	0.000
Criminality	0.074	284	0.001	0.987	284	0.000
Addiction	0.072	284	0.001	0.988	284	0.016
Lie	0.075	284	0.001	0.985	284	0.014

a. Lilliefors Significance Correction

Table 2: Tests for normality from within individual subject groups

Variable	Course	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	*df*	*p*	Statistic	*df*	*p*
Marlowe Crowne	1	0.078	72	0.200*	0.986	72	0.579
	2	0.115	61	0.044	0.968	61	0.116
	3	0.279	6	0.158	0.864	6	0.204
	4	0.096	51	0.200*	0.987	51	0.835
	5	0.097	50	0.200*	0.980	50	0.545
	6	0.126	44	0.075	0.955	44	0.086
Maths diagnostic score	1	0.133	72	0.003	0.954	72	0.011
(1st Term)	2	0.149	61	0.002	0.960	61	0.043
	3	0.262	6	0.200*	0.902	6	0.385
	4	0.142	51	0.012	0.959	51	0.074
	5	0.107	50	0.200*	0.966	50	0.166
	6	0.146	44	0.019	0.947	44	0.044
Psychoticism	1	0.147	72	0.001	0.943	72	0.003
	2	0.160	61	0.001	0.950	61	0.015
	3	0.333	6	0.036	0.873	6	0.238
	4	0.136	51	0.020	0.942	51	0.015

	5	0.118	50	0.081	0.976	50	0.399
	6	0.188	44	0.000	0.887	44	0.000
Extraversion	1	0.115	72	0.019	0.952	72	0.008
	2	0.118	61	0.034	0.954	61	0.022
	3	0.234	6	0.200*	0.789	6	0.047
	4	0.166	51	0.001	0.914	51	0.001
	5	0.120	50	0.069	0.969	50	0.210
	6	0.208	44	0.000	0.920	44	0.005
Neuroticism	1	0.071	72	0.200*	0.982	72	0.378
	2	0.084	61	0.200*	0.976	61	0.287
	3	0.288	6	0.131	0.869	6	0.222
	4	0.149	51	0.006	0.943	51	0.016
	5	0.116	50	0.089	0.977	50	0.434
	6	0.097	44	0.200*	0.981	44	0.667
Lie	1	0.112	72	0.026	0.977	72	0.211
	2	0.090	61	0.200*	0.976	61	0.282
	3	0.217	6	0.200*	0.945	6	0.700
	4	0.088	51	0.200*	0.977	51	0.423
	5	0.082	50	0.200*	0.979	50	0.509

	6	0.074	44	0.200*	0.967	44	0.235
Addiction	1	0.080	72	0.200*	0.968	72	0.067
	2	0.123	61	0.023	0.976	61	0.265
	3	0.234	6	0.200*	0.854	6	0.168
	4	0.143	51	0.011	0.966	51	0.146
	5	0.108	50	0.200*	0.975	50	0.380
	6	0.112	44	0.200	0.977	44	0.533
Criminiality	1	0.058	72	0.200*	0.983	72	0.464
	2	0.084	61	0.200*	0.976	61	0.283
	3	0.213	6	0.200*	0.924	6	0.532
	4	0.118	51	0.073	0.963	51	0.107
	5	0.101	50	0.200*	0.969	50	0.206
	6	0.094	44	0.200*	0.956	44	0.096

a. Lilliefors Significance Correction

*This is a lower bound of the true significance.

(1 = Business Foundation Year, 2 = Business Management, 3 = Dietetics, 4 = Adult Nursing, 5 = Psychology, 6 = Sports)

APPENDIX 3.2 STUDY 2 (INTERVENTION)

Normality tests for the intervention data of the Year Long Intervention study.

Table 1: Normality tests performed on data from all of the participants

Variable	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	*df*	*p*	Statistic	*df*	*p*
Mathematics diagnostic	0.140	41	0.041	0.948	41	0.058
Psychoticism	0.191	38	0.001	0.869	38	0.000
Extraversion	0.179	38	0.003	0.934	38	0.027
Neuroticism	0.113	38	0.200*	0.938	38	0.035
Lie	0.113	38	0.200*	0.954	38	0.124
Add	0.152	38	0.026	0.947	38	0.070
Cri	0.091	38	0.200*	0.953	38	0.111
Actual (int)	0.189	61	0.000	0.809	61	0.000
Aspirational (int)	0.219	61	0.000	0.831	61	0.000
Estimated (int)	0.224	61	0.000	0.797	61	0.000
Actual (post)	0.199	61	0.000	0.765	61	0.000

Aspirational (post)	0.190	61	0.000	0.810	61	0.000
Estimated (post)	0.214	61	0.000	0.763	61	0.000
Change in Actual	0.151	61	0.002	0.934	61	0.003
Change in Aspirational	0.167	61	0.000	0.898	61	0.000
Change in Estimated	0.192	61	0.000	0.883	61	0.000

a. Lilliefors Significance Correction

*. This is a lower bound of the true significance.

APPENDIX 3.3 STUDY 2 (INTERVENTION) MISSING DATA

Missing data analysis for the intervention data of the Year Long Intervention study.

Table 1: Result of Mann Whitney tests comparing the participants who had provided complete data was available with those where complete data on study habits was not available

Variable (incomplete study data/complete study data)	Median	Valid N	z	p (exact 2-tailed)	r
Age	19/ 19	249/ 41	-0.292	0.771	-0.017
Gender	1.13/ 1.07 (mean)	308/ 57	-0.533	0.606	-0.028
Year mathematics qualification achieved	2005/ 2006	227/ 35	-1.397	0.163	-0.086
Mathematics Diagnostic score	5/ 5	253/ 41	-0.283	0.778	-0.017
Psychoticism	7/ 6	247/ 38	-1.712	0.087	-0.101
Extraversion	17/ 14.50	247/ 38	-2.581	0.010	-0.153
Neuroticism	12/ 13.50	247/ 38	-0.065	0.949	-0.004
Lie	9/ 11.00	247/ 38	-1.246	0.214	-0.074
Addiction	11/ 11.00	247/ 38	-0.441	0.661	-0.026
Criminality	14/ 13.00	247/ 38	-0.727	0.469	-0.043

Table 2: Median and means for the data split according to condition and the formation of implementation intentions.

Group	*N*	Intervention/ Post actual study	Median	Mean (Standard Deviation)
Control	33	Intervention	11	15.28 (16.77)
		Post	13	15.82 (22.09)
Treatment (no II*)	11	Intervention	7	10.55 (11.67)
		Post	14	18.50 (16.27)
Treatment (with II*)	17	Intervention	5	11.79 (14.25)
		Post	11	16.85 (17.28)

*implementation intentions

APPENDIX 3.4 STUDY 3

APPENDIX 3.4.1 PRELIMINARY ANALYSIS

Aspirations prior to the intervention

187 of the 228 students who had completed the first questionnaire had provided complete data on their study aspirations and had also completed the mathematics diagnostic test. Preliminary examination of the data suggested that 33.7% of these participants had no aspiration to study within the support centre at the time of the first questionnaire. Normality checks were carried out (see Table 1 in Appendix 3.4.2) on the mathematics scores of both groups which suggested that the deviation from normality was statistically significant. A Mann-Whitney test showed that maths diagnostics scores were lower amongst those whose aspirations were zero (*Mdn* = 5) compared to those whose aspirations were greater than zero (*Mdn* = 6) at the intervention stage, $U = 3127$, $z = -2.248$, $p < 0.025$, $r = -0.164$.

In addition to differences in mathematics scores between these two groups it was also suggested that due to the difference in initial aspiration, the effectiveness of implementation intentions would be reduced if participants initially did not intend to use the MSC compared to those who did. As the intervention was aimed at assisting participants change their study habits such that their actual behaviours were closer to their intended behaviours, it was decided to separately analyse the data from those with aspirations of zero and those with non-zero aspirations. It is suggested that those with aspirations of zero feel they do not need mathematics support and those who perceive that their mathematics skills could be improved reported aspirations greater than zero.

Baseline usage measures

A check was made at baseline to ensure that there was no significant variation between the control and treatment groups on the three measures of actual, aspirational and estimated usage variables prior to the intervention. It was expected that there would be a difference between those with aspirations equal to zero and those with aspirations greater than zero. However, it was also expected that there would be no significant difference between control and treatment conditions within the same aspiration group. Data from the treatment group was examined to assess the compliance with the tasks involved as part of the formation of the implementation intentions. As a result it was found that within the control group there were 18 participants who had not completed the task sufficiently to assume that they had formed implementation intentions.

It was not possible to ascertain if these participants has formed implementation intentions or not. Of the 18 where this ambiguity existed 10 had identified areas of improvement, obstacles preventing study along with a time when they could engage with mathematical study. As with the rest of those who had only partially completed the task it was not possible to categorise these participants into one of the pre-existing conditions. As such their data had been separated from the treatment group and referred to as 'ambiguous' in the text. Furthermore, analysis in this section will only include the control and treatment groups as shown below.

Table 1: Actual, Aspiration and Estimated usage of the mathematics support centre for both control and treatment conditions

	Group	Actual Median, mean (SD)	Aspiration Median, mean (SD)	Estimate Median, mean (SD)
Aspirations = 0	Control *N* = 24	0, 0.33 (1.44)	0, 0 (0)	0, 0 (0)
	Treatment *N* = 23	0, 0 (0)	0, 0 (0)	0, 0.35 (1.67)
	Ambiguous *N* = 15	0, 0 (0)	0, 0 (0)	0, 0 (0)
Aspirations > 0	Control *N* = 56	0, 1.45 (3.13)	7.5, 11.32 (11.65)	4, 8.13 (11.23)
	Treatment *N* = 65	0, 2.85 (8.95)	8, 12.28 (14.33)	6, 9.32 (11.98)
	Ambiguous *N* = 3	0, 3 (5.2)	9, 10.33 (3.22)	15, 13.33 (2.89)

From Table 1 (above), there appeared to be a noticeable difference in the actual, aspirational and estimates of the number of hours that participants studied across the groups. Specifically, the difference was most observable between participants who had aspirations = 0 (means of approximately 0) and those with aspirations > 0 (means greater than 0, actual approximately 5, aspirational approximately 11 and aspirational approximately 10). Within aspiration groups there seemed to be less variation in the participants reported number of hours engaged with study. In all but one group (ambiguous group) the actual mean number of hours studied was less than the mean aspirational hours reported and an estimated study time that was greater than the actual but less than the aspirational figures.

A Kruscal-Wallis test was performed to test for differences in Actual, Aspiration an Actual usage data between the four groups summarised above in Table 1 (data from the ambiguous group has not been included). A significant difference between the groups on all three measures Actual usage, $H(3) = 12.414$, $p < 0.001$; Aspirational, $H(3) = 103.375$, $p < 0.001$; Estimated, $H(3) = 87.901$, $p < 0.001$ was found. Furthermore, it was predicted that at baseline there should be no difference between control and treatment groups within the two groups of Aspirations = 0 and Aspirations > 0. Mann-Whitney tests were performed to test for differences between control and treatment groups for participants in each aspiration group, the results of which are reported in Table 2 (below).

Table 2: Mann-Whitney U tests between control and treatment conditions

		U	*Z*	*p* (2 tailed)	*r*
Aspiration = 0	Actual	253.000	-1.399	0.162	-0.204
(baseline)	Aspirational*	552.000	0	0	0
	Estimate	264.000	-1.022	0.307	-0.149
Aspiration > 0	Actual	1787.500	-0.211	0.833	-0.019
(baseline)	Aspirational	1811.500	-0.044	0.965	-0.004
	Estimate	1681.500	-0.722	0.470	-0.066
Aspiration = 0	Actual	239.500	-1.131	0.258	-0.165
(post)	Aspirational	259.000	-0.472	0.637	-0.069
	Estimate	260.000	-0.476	0.634	-0.069
Aspiration > 0	Actual	1817.000	-0.017	0.987	-0.002
(post)	Aspirational	1560.000	-1.359	0.174	-0.124
	Estimate	1621.500	-1.041	0.298	-0.095

*aspiration = 0 so numbers are nonsense

The above results (as presented in Table 2) suggest that there was no significant difference at baseline in any of the scores on any of the three self-report measures between control and treatment groups within either of the aspiration groups. However, the analysis on post-intervention scores suggest that there may be no difference in the usage metrics between the control and treatment groups. All subsequent analysis involving the effectiveness of implementation intentions was carried out using the groupings described in Table 2. Furthermore, data from participants in the Ambiguous groups was not used.

Measures of usage

Both aspirations and estimates aim to quantify the amount of time spent studying in the mathematics support centre in the coming month. Actual values aim to measure the amount of time spent engaged with study over the past month. It was decided to focus primarily on the change in actual time spent studying mathematics. To supplement this measure the difference between their actual time spent studying after the intervention and their aspirations of study prior to the intervention was calculated (Actual – Aspiration). This measure indicated how close an individuals behaviour was to their aspired behaviour. Values close to zero suggested behaviour that was very close to their aspired behaviour. Values lower than 0 suggests usage that was less that aspired to. Values above 1 suggest the time spent studying was more than aspired to. Descriptive data for the new composite measure is shown in

Table 3 (below).

Table 3: Descriptive data for the composite variables derived from the original measures of actual, aspirational and estimated usage of the mathematics support centre

		Median, Mean (S.D.) Aspiration = 0	Median, Mean (S.D.) Aspiration > 0
Actual (Post) subtract Aspiration (Pre)	Control	0, 1.13 (3.42)	-5, -7.29 (11.41)
	Treatment	0, 1.83 (4.32)	-5, -6.02 (14.85)
	All	0, 1.47 (3.86)	-5, -6.61 (13.33)

From Table 3, the data would suggest that those with aspirations equal to zero scored higher on the measures of usage that aimed to describe how close the actual amount of time spent study mathematics was to either aspirations. Furthermore, the spread of scores appeared to be larger in the group where aspirations were greater than zero. However, considering that those participants in the aspirations = 0 group had by definition aspirations of zero at baseline (and very low if not zero estimated study times) it seems plausible that the difference scores reported in Table 3 by the aspirations = 0 group were greater than those reported by the aspirations > 0 group. This also further highlighted the need to analyse the two groups separately in the main analysis (see Sections 7.3.3 and 7.3.4). Comparing the control and treatment groups within both aspiration groups suggest that there are small differences in the mean and median scores on the two measures. However, the large standard deviations and the small differences in the means indicate these differences could likely be due to chance.

Appendix 3.4.2 Study 3 (Intervention)

Table 1a: Tests of normality using Kolmogorov-Smirnov tests for aspiration = 0

	Control			Treatment		
	Statistic	*df*	*p*	*Statistic*	*df*	*p*
Mathematics Diagnostic	0.125	24	0.200*	0.949	23	0.275
Marlowe Crowne	0.140	24	0.200*	0.955	23	0.362
Psychoticism	0.174	24	0.057	0.958	23	0.426
Extraversion	0.204	24	0.011	0.951	23	0.309
Neuroticism	0.184	24	0.035	0.968	23	0.635
Actual (Intervention)	0.509	24	0.000	-	-	-
Aspiration (Intervention)	-	-	-	-	-	-
Estimate (Intervention)	-	-	-	0.215	23	0.000
Actual (Post)	0.504	24	0.000	0.497	23	0.000
Aspiration (Post)	0.454	24	0.000	0.564	23	0.000
Estimate (Post)	0.495	24	0.000	0.471	23	0.000
Actual (Post) – Aspiration (Pre)	0.504	24	0.000	0.497	23	0.000
Actual (Post) – Actual (Pre)	0.514	24	0.000	0.497	23	0.000

Test results with Lilliefors Significance Correction applied

*. This is a lower bound of the true significance.

Table 1b: Tests of Normality using Kolmogorov-Smirnov tests for aspiration > 0

	Control			Treatment		
	Statistic	*df*	*p*	*Statistic*	*df*	*p*
Mathematics Diagnostic	0.198	54	0.000	0.152	64	0.001
Marlowe Crowne	0.074	54	0.200*	0.083	64	0.200*
Psychoticism	0.167	54	0.001	0.141	64	0.003
Extraversion	0.202	54	0.000	0.126	64	0.013
Neuroticism	0.131	54	0.022	0.093	64	0.200*
Actual (Intervention)	0.386	54	0.000	0.385	64	0.000
Aspiration (Intervention)	0.180	54	0.000	0.286	64	0.000
Estimate (Intervention)	0.206	54	0.000	0.248	64	0.000
Actual (Post)	0.277	54	0.000	0.307	64	0.000
Aspiration (Post)	0.161	54	0.001	0.244	64	0.000
Estimate (Post)	0.209	54	0.000	0.256	64	0.000
Actual (Post) – Aspiration (Pre)	0.200	54	0.000	0.164	64	0.000
Actual (Post) – Actual (Pre)	0.239	54	0.000	0.230	64	0.000

Tests with Lilliefors Significance Correction applied

*. This is a lower bound of the true significance.

Table 2: Kendall's tau correlation coefficients between Marlowe Crowne scores and measures of ability, personality and support centre usage

		Aspiration = 0		Aspiration > 0	
	All	Control	Treatment	Control	Treatment
	N = 165	*N* = 24	*N* = 23	*N* = 54	*N* = 64
Mathematics Diagnostic	-0.110	-0.063	0.145	-0.353**	0.012
Psychoticism	-0.194**	-0.206	-0.055	-0.405**	-0.102
Extraversion	0.037	0.067	0.184	-0.151	0.109
Neuroticism	-0.198**	0.008	-0.331*	-0.054	-0.317**
Actual (Intervention)	0.002	0.056	.	0.156	-0.092
Aspiration (Intervention)	-0.115*	.	.	-0.217*	0.036
Estimate (Intervention)	-0.090	.	0.303	-0.106	-0.018
Actual (Post)	-0.024	-0.131	0.169	0.038	-0.013
Aspiration (Post)	-0.088	-0.091	0.216	-0.113	-0.044
Estimate (Post)	-0.039	-0.047	0.339	-0.033	-0.011
Actual (Post) – Actual (Pre)	-0.026	-0.154	0.169	-0.031	0.026
Actual (Post) – Aspiration (Pre)	0.127*	-0.131	0.169	0.224*	0.013

*$p < 0.05$, **$p < 0.01$

Appendix 3.4.3 4-Way Analysis

The Time*Aspiration*Condition*Psychoticism interaction was significant, $F(2, 151) = 3.369$, $p = 0.037$. This results suggests that the Actual amount of time that participants used the Mathematics Support Centre was varied across levels of the factors Time, Aspiration, Condition and psychoticism.

However, to understand the meaning of this 4-way interaction, a systematic process of breaking down each significant n factor interaction into a series of n-1 factor analyses was used. Any interaction that was not significant was not decomposed and explored any further. The interaction was explored further by carrying out a series of 3 Way analysis looking at the Time*Aspiration*Condition interaction across all levels of psychoticism (low, medium and high). The Time*Aspiration*Condition interaction was found to be not significant at medium [$F(1, 102) = 0.510$, $p = 0.477$] and high [$F(1, 20) = 3.823$, $p = 0.065$] levels of psychoticism. However, it was found to be significant for participants with a low score on the psychoticism scale, $F(1,25) = 8.277$, $p = 0.08$. The interaction plots of Time*Aspiration*Condition are shown in Figure 1 and Figure 2.

Figure 1: Interaction plot showing the relationship between Condition and improvements in the amount of time spent studying mathematics in the Mathematics Support Centre for those with low psychoticism scores and Aspirations equal to zero.

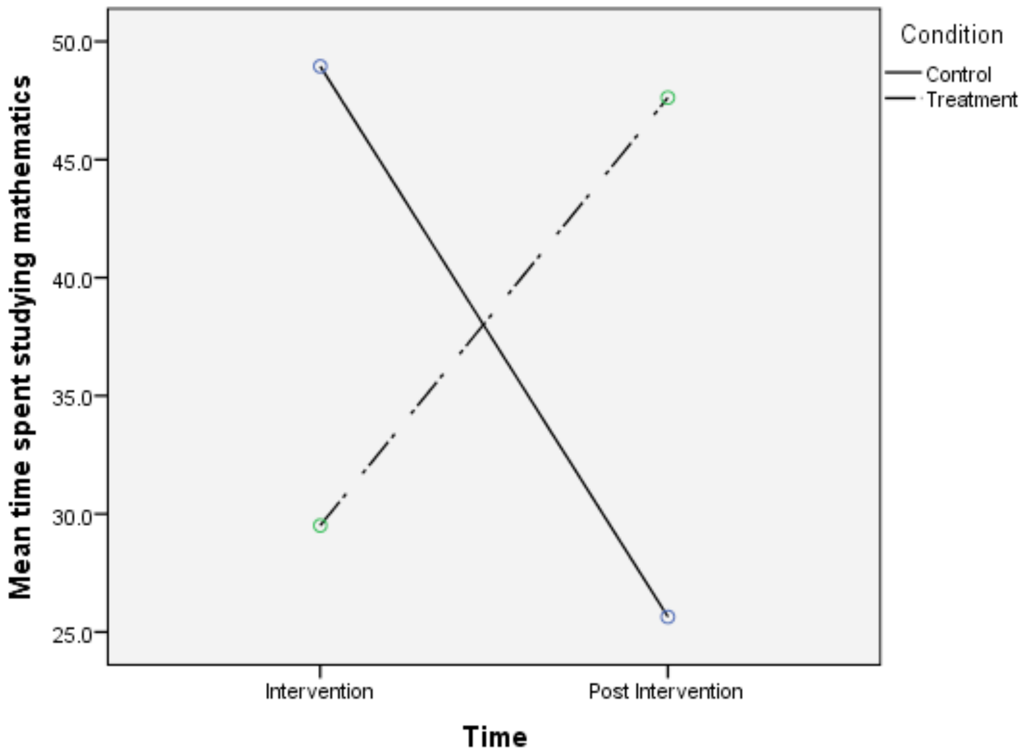
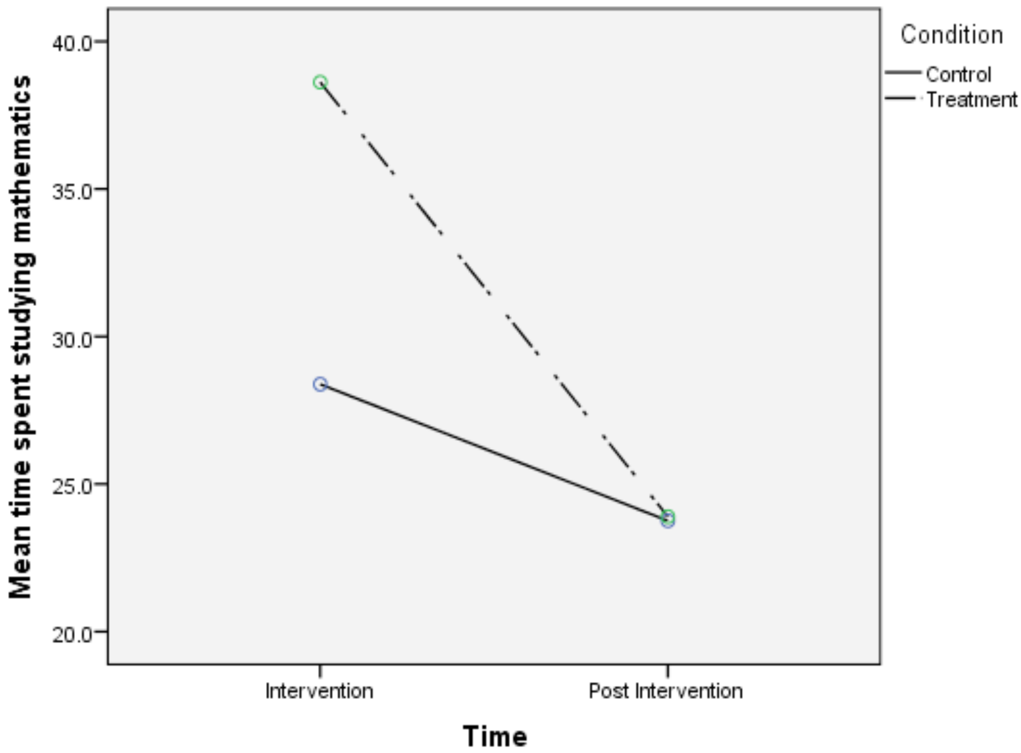


Figure 2: Interaction plot showing the relationship between Condition and improvements in the amount of time spent studying mathematics in the Mathematics Support Centre for those with low psychoticism scores and Aspirations greater than zero.



The significant Time*Aspiration*Condition interaction for participants with low scores on the psychoticism scale was explored further by carrying out an analysis of the Time*Condition interaction across both levels of Aspiration (equal to zero and greater than zero) for participants who had low scores on the psychoticism scale. It was found that the Time*Condition interaction was not significant when Aspirations equalled zero, $F(1,5) = 2.452$, $p = 0.178$. The Time*Condition interaction was also found to be not significant when Aspirations were greater than zero, $F(1,18) = 1.191$, $p = 0.290$.

APPENDIX 4.1 ETHICAL APPROVAL FOR THE RESEARCH

COVENTRY UNIVERSITY ETHICS COMMITTEE (Form 1)

POSTGRADUATE STUDENT & STAFF APPLICATION FOR ETHICAL APPROVAL

Name Roy Bhakta	**E-mail** roy.bhakta@coventry.ac.uk
Designation / Subject & Faculty: PhD Student/ SIGMA – Engineering and Computing	
Title of Study: The moderating role of personality on the effectiveness of implementation intentions aiming to increase engagement with mathematics support services	

1. Summary of proposal

The proposed research aims to show how mental constructions which may exist to bridge the intention-behaviour gap may be effected by a number of personality traits and thus explain the low levels of effectiveness of some currently existing strategies for encouraging self help and usage of support mechanism in mathematics. For the investigation of the effectiveness of implementation intentions it is proposed that data are gathered pre and post intervention through questionnaires measuring:

- Mathematics support usage
- Mathematical ability (using a mathematics diagnostic questionnaire)
- Personality/attitude (Marlowe Crowne and Eysenck Personality Questionnaire)

Interviews will be used to discus the factors which may inhibit usage and to explore ideas which may not be addressed in the questionnaires.

The intervention will consist of a brief talk to students which will be given to all participants in the treatment groups. The aim of the intervention will be to facilitate the formation of implementation intentions by the students, the effectiveness of which will be measured through the instruments described above.

The proposed study has outcomes that will benefit both the participants and the larger population from which the participants are drawn. The questionnaire data will provide a broad overview of the personalities/attitudes of students taking non-mathematical courses (e.g. nursing, business, psychology, etc.) and their feelings towards mathematics support. Support can then be modified where possible to increase usage.

2. Sample of participants

Data will be gathered from students taking non-mathematical courses (e.g. Nursing, Business, Design and Psychology)

3. Site/s location

Coventry University

*Tick / Cross. *Where answered 'NO', please give reasons on separate page.*	**Yes**	**No***
4. Scientific background, design, method and conduct of the study. a) Have you given a justification for the research?	x	
b) Have you commented on the appropriateness of the design, the perceived benefits, risks and inconveniences to participants?	x	
5. Recruitment of participants. Have you provided a comprehensive account of the characteristics of the population including the process for obtaining access as well as the inclusion and exclusion criteria?	x	
6. Care and protection of research participants and researcher. Have you given an account of any interventions, situations and risks which have the potential to cause harm to the participants and researchers?	x	
7. Access, storage, security and protection of participants' confidentiality. Have you identified who will have access to the data and what measures have been taken to ensure confidentiality and compliance with the Data Protection Act?	x	
8. Informed Consent. Have you given a full description of the process for requesting and obtaining informed consent?	x	
9. Community considerations. Have you considered how this study will benefit the participants or the community from which they have been drawn?	x	
10. Participant information Sheet and consent form.	x	

W / HLS / Student / Ethics / CU Ethics Forms / CU Ethics PG and Staff Form 1
October 2005

Are these attached?			
11. Source of External Funding if any **SIGMA (CETL) funding**			
Signature of student / staff [redacted]	Address AS 320 - D	Date 22/ 04/ 2008	
Signature of Supervi[redacted]	Print Name C. WOOD Internal Address JS242	Date 22/ 04/ 2008	
Signature of Chair	o Approved. o Approved with the conditions below:	Date	
Conditions / Comments:			

Please complete in full and return to: **Research Manager, CU Ethics Committee, Richard Crossman RCG17, Coventry University.**

This form should be accompanied by the full research study proposal, or the COREC form if applicable. Further help & information can be found on W / HLS / Student / Ethics or call Rhoda Morgan on 024 7679 5945, or e-mail r.morgan@coventry.ac.uk.

W / HLS / Student / Ethics / CU Ethics Forms / CU Ethics PG and Staff Form 1
October 2005

S.sanghera@coventry.ac.uk.

Coventry University ETHICS Committee

Form 4 – Ethics Peer Review

1.	Reference No:	PG23/08
2.	Title of Study:	The moderating role of personality on the effectiveness of implementation intentions aiming to increase engagement with mathematics support services
3.	**Scientific Background, Design and conduct of the study**: Although the background provides useful information pertaining to the rationale personality per se is not mentioned. The use of the term 'attitudes' may reflect an individuals personality somehow but is a different construct to personality. As this is one of the key aspects to be measured – and a key research question in the aims - it would be useful for the reader to know why personality is important and how it relates specifically to the research question. Is personality to be measured both pre and post intervention as suggested in '1. Summary of proposal'. This is not clear when it will occur if it will. I am sure that the investigators are trying to modify behaviour rather than personality. Is this reflected in measuring the attitudes to support services pre and post? Will this occur? Methods: Standard questionnaires are to be used initially – fine (is it attitudes or personality being gathered?). Who will the mathematics diagnostics and usage be piloted on and how? Presumably a non-mathematical course? When the implementation intention is undertaken, will the staff to deliver this be randomly assigned? Will all students get chance to be involved in hearing about or using the techniques so they are at no disadvantage to those who were told about it? Will those not getting the implementation initially advice act as a control group and then receive the information? How will the use of the implementation be assessed? Via questionaire again? At what time point? Outcomes: The PhD thesis is not the main outcome of this study (presumably part of a larger research programme). These should also include the benefits to the participant rather than this just being mentioned in the introductory sentence of this section. This should also be added to the 'What are the benefits of taking part' section of the participant information sheet.	
4.	**Recruitment of participants**: Minor grammatical point, the application states ' …(all criteria must be met)…', but as there are only two this should be 'both' unless there are more to be added. Also, the first criteria states …' enrolled on either a non-mathematical course (e.g. Nursing, Business, Psychology etc..' but has no 'or' option. If both this and the second criteria are both to be met please reword. Please note that psychology is likely to have some mathematical aspect to the course due to potential use of parametric statistical process. Is there a 'cut-off' as to what is a small amount of mathematical involvement? How will this be determined? Please state which criteria will be used to designate the sample as representative of the overall intake of students from non-mathematical courses (age, gender, A-level / equivalent entry points etc). This is likely to be very different for some courses (e.g.	

	nursing).
5.	**Care of researcher and participants and protection of research participants' confidentiality**: No issues arising. However, please note the comments on research design and enabling all students to have access to the implementation strategy after the experimental group has done so.
6.	**Informed consent**: OK.
7.	**Community considerations**: n/a
8.	**Information sheet**: Form OK – see above comment.
9.	**Consent form**: OK.
10.	**Comments on the ethical aspects of the proposal**: Key point is that all subjects should receive potential benefits of knowing about the implementation strategies. No major ethical concerns, more concern on clarity of the methods and design.

11.	**Recommendations**	
	Approved with **no** amendments	
	Approved subject to specified conditions.	✓
	Reject	
12.	**Completed by**:	**Date**: 31/03/08
13.	**Re-submission**	
	Approved	
	Completed by:	**Date:**

Please return this form electronically to s.sandhu@coventry.ac.uk and please DO NOT CONTACT THE APPLICANT DIRECTLY.

Document: Project proposal submitted for ethics approval
Date: 22 April 2008
Version: 5.1

The moderating role of personality on the effectiveness of implementation intentions aiming to increase engagement with mathematics support services

Background

'Advanced economies need an increasing number of people with more than minimum qualifications in mathematics to stay ahead in international competitiveness and, in particular, to effectively exploit advances in technology. An adequate supply of young people with mastery of appropriate mathematical skills at all levels is vital to the future prosperity of the UK'
(Smith, 2004, p.12)

Over the past two decades the types of qualifications that have been accepted as valid for entry onto higher education courses has been relaxed by many institutions; the result of this has been a greater influx of students into higher education combined with greater variation in educational and social backgrounds. A by-product of the influx of new students is the variation in attainments and potential future attainments of the students (Engineering Council UK, 2000). As the overall intake of students into higher education increases, the numbers of students who may not be able to cope with the mathematics involved in their particular course have also correspondingly increased.

Widening the participation in higher education would suggest that there should be a corresponding rise in the proportion of skilled workers in the workforce. However with the widening of entrance qualifications the number of students who are entering universities with an inadequate mathematical background has risen substantially; such students are more prone to failing or dropping out due to mathematical inadequacy. Wolf (1997) discusses the differences between England and other parts of the world, identifying the non-compulsory nature of mathematics study once the compulsory phase of education has been completed in English schools. This feature sets the English education system apart from the majority of other developed countries where mathematics is to some extent compulsory and seen by students prior to entering university as an essential deciding factor for acceptance onto university courses.

Many types of support are currently available and also in development which aim to reduce the mismatch by helping students to improve their mathematical skills once in university. One such support mechanism is the mathematics drop-in support centre; students can visit without a prior appointment and seek assistance with their mathematical problems. The quality of the support and its potential effectiveness in raising or improving the mathematical skills of students becomes irrelevant if students do not use the service. This research project looks into exploring why students who have acknowledged to themselves the need to undertake some form of supplementary study or engagement with support have a behaviour which conflicts with their own best interest e.g. tendencies not to use mathematics drop-in services

Dweck (1999) suggests that many students' personal view of intelligence is that either it is genetically pre-determined or it is acquired as a result of prolonged study. This could suggest one possible reason why students may not engage with support mechanisms i.e. if students' have come to the conclusion that achievement in mathematics is beyond their reach because they have not been born with innate mathematical ability. More recent research (Solomon, 2006; Macrae et al, 2001) also points to the effect of student attitudes towards mathematics with Sheffield and Hunt (2007) looking at the effects of anxiety and working memory on mathematics performance. Macrae et al (2001) highlight how little research has been done with regards to attitudes of higher education students in England.

Attitudes have for a long time been believed to be strong predictors of behaviour e.g. Theory of Planned Behaviour (Ajzen et al, 2007). Recent research is suggesting that attitudes are only a good predictor of intentions and not behaviours. It is suggested that some other mechanisms such as the creation of implementation intentions (Webb and Sheeran, 2007) maybe acting to bridge the gap between intention and behaviour and could explain why behaviours are not so well predicted by attitude. Implementation intentions being short statements or plans constructed by an individual that link a specific situational cue to a desired action or behaviour (If X then Y) e.g. "If it is Tuesday then I will go to the gym after work".

A meta analysis by Webb and Sheeran (2006) on behaviour change suggests that there is a considerable amount of research looking at changing intentions and behaviours with the use of implementation intentions e.g. Condom use (Caron et al, 2004). Data would suggest that the formation of implementation intentions does produce behaviour change in health behaviour, however a review of the literature also suggests that a significant number of studies may lack measures of one or more of the following:

- Intention
- Behaviour
- Control group

Currently there is little research related to attitudes of non-mathematics specialist students in higher education and none relating to exploring the intention and behaviour gap in the domain of mathematics education and support. Recent research has also hinted at how the effectiveness of individuals in being able to accomplish certain behaviours maybe influenced by their personality (Song et al, 2006; Hooft et al, 2005). The research suggests that for some individuals the difference between intention and behaviour can be explained by differences in the personality traits of individuals. Through the research outlined below it is hoped that an increased understanding of the intention-behaviour relationship can increase the usage of mathematics support services by students who need extra support. At the same time it is hoped to supplement other research in the area of implementation intentions by taking into account all of the measures described above (including personality) whilst applying what has been learned in the area of health to that area of mathematics support.

Attitudinal (including personality) research up until now in the area of mathematics has been limited to students who have had a continuous history of studying mathematics, for example engineering students (Shaw and Shaw, 1997). This is significantly different from the students who are at the focus of this research. Students who will be involved in this research do not have a continuous history of mathematics and in many cases have made a decision prior to entering university that they did not want to study mathematics further after their compulsory schooling was complete.

The research proposed in this proposal will contribute to the current body of knowledge by showing how mental constructions which may exist to bridge the intention-behaviour gap may be effected by a number of personality traits. Following on from this, the research will attempt to explain why some currently existing strategies for encouraging self help and usage of support mechanism in mathematics may be failing or not having as high an effect as intended.

Aims of the research

The proposed research aims to show how mental constructions which may exist to bridge the intention-behaviour gap may be effected by a number of personality traits and thus explain the low levels of effectiveness of some currently existing strategies for encouraging self help and usage of support mechanism in mathematics; and this leads to the specific research questions:

- What is the relationship between personality and the effectiveness of implementation intentions?
- How effective is the construction of implementation intentions for increasing the probability that students will use mathematics support provision?

Objectives:

- To gather personality data from students before and after a planned intervention that is aimed at facilitating the formation of implementation intentions.
- To gather performance data from students relating to proficiency at performing contextual questions and abstract questions before and after the interventions.
- To gather data on the usage of the mathematics support services

Sample Selection

For the investigation it is proposed that data are gathered through a combination of interviews and questionnaires. Data will be gathered from students in the first year of study. The criteria for participation in the study are as follows (both criteria must be met):

- Currently enrolled on a non-mathematical course (e.g. Nursing, Business, Psychology, etc. the term non-mathematical here defines a course where the equivalent of an A-level in mathematics is not required on entry and where 20% or less time is devoted to mathematical study)
- Students must be in their first year of an undergraduate degree/diploma course

All eligible students will be informed of the study either in writing or through a course tutor and asked to volunteer to participate. To assist in the recruitment of participants, flyers and leaflets will be made available to potential volunteers. These leaflets will briefly describe the research and potential benefits for those who may wish to volunteer. Information on how then to proceed with volunteering and participating in the research will be attached to the flyer (e.g. contact email address and where further information on the research can be found). Flyers will ideally be distributed in key locations where students are known to pass through regularly e.g. library, common areas. However, before the flyers can be distributed requests and authorisation will be sought from those in charge of those locations.

Volunteers will be given a participant information sheet and consent form (see appendices A and B). Students who wish to participate in the focus groups and interviews will be asked to complete and return these forms as soon as possible. From the pool of willing participants, a random sample will be selected to take part in the focus groups such that the sample is representative of the overall intake of students from non-mathematical courses. Participants who exhibit interesting responses (in relation to the research) will be invited back to participate in structured interviews to explore their attitudes further. As students from different disciplines may be composed of students with different backgrounds (mathematical ability, A-level subjects taken, age etc) each discipline will be treated as a subgroup. When sampling, each sample representing a particular course will be such that the following characteristics in the sample will be representative of the same characteristics in the population (i.e. the students taking the course):

- Age
- Mathematics qualification achieved prior to entry
- Number of years since the qualification was obtained
- Gender
- Home, EU or International Student

Students will be asked to provide this information at the time of completing the questionnaires by completing a small number of demographics type questions (see appendix H).

Methodology

For the study a mixed methodology will be used to gather qualitative and quantitative data through a combination of interviews and questionnaires that will aim to gather personality, mathematical competence and usage data. To reduce the effects of social desirability bias which may manifest itself in the questionnaire data, the Marlowe Crowne social desirability test will be used with all participants in both phase 1 and 2. Data collection will involve the two phases as show below.

Phase 1 (Pilot) – Short exploratory interviews (questions to be asked are outlined in the interview schedule located in appendix C) with students to explore the reasons students may have for not using mathematics support services. Mathematics diagnostics and usage (measuring intended and actual usage of mathematics support provision) questionnaires will be trialled to ensure the suitability of questions (see appendix F and G). The usage questions (for measuring behaviour) in appendix G include several questions that are asking the same question but worded slightly differently. During the analysis of pilot data, an analysis of the responses will be used to refine the diagnostic questions and remove items in the usage questionnaire that are not needed to obtain accurate information relating to intended and actual usage of mathematics support services. Phase 1 participants will be students who are enrolled on a nursing course at Coventry University.

Phase 2 (Main Data Collection) – Pre intervention data will be collected using the four instruments described below in term 1, post intervention data will be collected again using the same four instruments in term 3. Personality will be measured both pre and post intervention as it will not be assumed that the personality construct is stable over time. Although the aim of the treatment is not to change behaviour and not personality; personality will still be measured so before and after the interventions so that it can be shown that personality was stable over the time span of the study. If personality did fluctuate significantly between those two points in time then it would be significantly harder to ascertain the personality of an individual during the treatment phase if it was measure only once.

Although it is not personality that is being modified; it is hoped that through its measurement at two points in time it can be confirmed that it is stable over the time span of the research. Instruments to be used during the data collection phase are:

- Personality measurement - Eysenck Personality Questionnaire (EPQ) personality test (see appendix D)
- Social desirability questionnaire - Marlowe Crowne Social desirability test (see appendix E)

- Mathematics competency - Mathematics diagnostic questionnaire piloted and developed in Phase 1 (see appendix F)
- Support service usage – usage questionnaire piloted and developed in Phase 1 (see appendix G)

Supervision and training in the use of the EPQ and Marlowe Crowne test instruments is being given by Dr Clare Wood).

In term 2 the intervention (consisting of a brief talk to students) will be applied to all participants in the treatment groups this talk already takes place and is given by members of staff at the university and aims to inform students of the existence of mathematics support services around the university. Some staff will be asked to supplement their talks with an intervention; the aim of which will be to facilitate the formation of implementation intentions by the students. The intervention will be a simple request to ask students to think about a way in which they might be able to use the support services more and write this down in the form of a 1 line statement or plan (If X then Y). Once the students have constructed and written down the plan, these will be collected and later analysed by looking for patterns in the plans constructed and also the quality (how well it addresses a specific barrier that prevents usage in addition to how well it adheres to the “If X then Y” pattern). A second technique for the intervention would be to use 2 versions of a questionnaire, the treatment version would guide students on the formation of interventions while those in the control condition complete another activity which does not include the formation of implementation intentions.

Ethics and Safety

Consideration has been made for the safety and protection of all participants in this study. The students involved will be interviewed in a non-threatening environment such as a seminar room. No physical risks are anticipated for either the interviewer or students.

Personal details will not be used in any report about the research. Interviews will be recorded to assist in analysis but these recordings will be held securely in a locked cabinet and the data they contain will only be used for the purposes of this research. Only members of the research team will have access to the completed questionnaires and recordings. Raw data relating to individuals will be kept for no longer than is necessary in order to complete the analysis and dissemination of the research. All results will be reported in a way that preserves confidentiality. Consent forms and raw data will be stored in locked cabinets in separate locations.

Not all of the students will be given instructions to construct implementation intentions, moreover as the study will run over one academic year, the students who are not in a treatment group will not have the opportunity to create these plans during their first year of study. However the treatment is a supplement to support they may already be receiving. In light of this there does not seem to be an immediate ethical issue for students who do not receive the treatment. Staff involved in the teaching of the students from control groups may at their discretion choose to use the treatment with their students after the data collection has ended. A short summary of the results and outcomes will be made available to all students who participated in the research; students can then make evaluations of the value of implementation intentions for themselves.

Outcomes

The proposed research has the following outcomes that will benefit both the participants and the larger population from which the participants were drawn:

- A PhD thesis discussing the effectiveness of implementation intentions on increasing the usage of mathematics support services at Coventry University.
- Good practice guidelines that aim to enhance the effectiveness of support at university for non mathematics specialists during their tertiary education.
- Dissemination of the results, analysis and good practice guidelines through conference presentations and publications.
- Through participation in the research, students will be able to explore their own study behaviour and possibly identify factors which may inhibit their effectiveness. Participants may also be able to identify ways in which they can improve the effectiveness of their study techniques.

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